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CHEMOTHERAPEUTIC EXPERIMENTS WITH CHAULMOOGRA AND ALLIED PREPARATIONS

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The work of Walker and Sweeney[2] aroused considerable interest among laboratory workers and was shortly afterward followed by reports along similar lines which apparently upset all prospects of working out a satisfactory chaulmoogra treatment for infectious diseases that are caused by acid-fast bacilli, particularly tuberculosis. On the other hand, most satisfactory results have been reported in the treatment of leprosy with chaulmoogra oil and its derivatives, in Hawaii; and, although these have not been duplicated in other parts of the world, the consensus of opinion with regard to the efficacy of chaulmoogra oil seems to be that the treatment brings about an improvement in the majority of leper patients, though a complete cure is not so frequent as the initial improvement of the patients leads us to hope for.

The great value of the work of Walker and Sweeney lies in their having demonstrated experimentally the possibility of working out certain fundamental problems in the chemotherapeutics of chaulmoogra treatment.

There are certain points in chaulmoogra therapy, disputed by clinical workers, which can be and have been decided by laboratory evidence. First of all, it has been demonstrated that

[1] Member, Philippine Leprosy Research Board.

[2] Walker, E. L., and Sweeney, M. A., The chemotherapeutics of the chaulmoogric acid series and other fatty acids in leprosy and tuberculosis, Journ. Inf. Dis. 1 (1920) 1.

chaulmoogra oil and some of its derivatives have a direct antagonistic action upon acid-fast bacilli, and experimental evidence allows us to deduce more definitely than does clinical observation that this action is not to be conceived as purely bactericidal, but rather in the sense of Walker's hypothesis. It can be shown by laboratory experiments that the direct antiseptic action of chaulmoogra oil is specific, in as much as chaulmoogra inhibits the growth of acid-fast bacilli in dilutions in which it has no such effect on the growth of non-acid-fast bacteria.

An attempt on the part of chemists to eliminate inert substances from chaulmoogra oil and its derivatives and thus concentrate the active principle, or to isolate the particular acid that would be most effective, yielded numerous preparations which appear to exert variable degrees of antiseptic action upon *Bacillus tuberculosis* in vitro.

It is claimed that valuable oils in chaulmoogra therapy of leprosy show a specific rotation of polarized light of about + 50°. In view of this claim it seemed of interest to compare the oils obtained from various closely related species of plants with each other as to their growth-inhibiting effect and, if quantitative differences were found, to study their relation to their power of rotating the plane of polarized light and other physical and chemical properties.

It is not my intention to claim that the results of such laboratory experiments as are presented herewith can be applied directly to the treatment of leprosy, but in view of the wide use of chaulmoogra therapy study of the experimental chemotherapy of this and related drugs should be continued.

These experiments were begun shortly after the paper of Walker and Sweeney came to my attention, because of the bearing this work has on the problem of chaulmoogra treatment of leprosy. The present investigation is an attempt to answer, by experimental laboratory evidence, questions on the following and other points in the problem of chemotherapy of infectious diseases that are caused by acid-fast bacilli.

I. EXPERIMENTS IN VITRO

1. The growth-inhibiting activity of chaulmoogra oil and its derivatives.
2. Comparison of the growth-inhibiting power of chaulmoogra with that of other vegetable and animal oils, rare and common.
3. The disinfecting power of the vapors of certain vegetable oils.
4. A survey of certain organic compounds as to their growth-inhibiting activity toward acid-fast bacilli in vitro.
5. An inquiry into the mechanism and nature of the growth-inhibiting effect of chaulmoogra and other vegetable oils.

II. EXPERIMENTS IN VIVO

1. The antiseptic effect of chaulmoogra oil toward acid-fast bacilli in vivo.
2. Pathological changes produced in the organs of experimental animals, normal and tuberculous, by injections of chaulmoogra preparations.
3. The chaulmoogra therapy of experimental tuberculosis in laboratory animals with particular reference to resulting immunity.
4. The antiseptic effect upon acid-fast bacilli in vivo of such organic compounds as have been found to have a high value in vitro.

Results are given in this paper and in papers being written of my own experiments which were continued along this line as a part of the research program of the Philippine Leprosy Research Board.

1. THE GROWTH-INHIBITING ACTIVITY OF CHAULMOOGRA OIL AND ITS DERIVATIVES TOWARD BACILLUS TUBERCULOSIS IN VITRO

The technic employed in the following experiments was very simple. Measured amounts of the oils were added to test tubes containing 10 cubic centimeters of 5 per cent glycerine agar and kept in boiling water for thirty minutes. They were then vigorously shaken and cooled quickly in a slanted position. When solidified the tubes were kept in an upright position overnight to drain off the water of condensation. After planting the cotton plug was sealed with paraffin. Incubation of planted tubes followed, readings being made in two and four weeks. With each set control cultures were made, one on plain glycerine agar and one on glycerine agar containing olive oil. In the tests of sodium salts of fatty acids a solution of green soap was used as a control. The dilutions of oils were made in olive oil, those of soaps in distilled water, and the total amount of dilution added to one tube was usually 0.1 cubic centimeter, never exceeding 0.5 cubic centimeter to a test tube.

The acid-fast culture used in these experiments was an old laboratory strain of *Bacillus tuberculosis*, human type, originally obtained from the Kitasato Institute for Infectious Diseases in Tokio. The culture grew well on slightly acid beef infusion agar to which 5 per cent glycerine had been added, producing a rather moist, well emulsifiable confluent growth, which was noticeable in from eight to ten days after planting. In inoculation of the medication and the control agar tubes a small loopful of young growth was placed on the surface of the slant to be inoculated, and distributed well over the entire surface

in as thin a film as possible. A diffuse growth resulted in the inoculated agar tubes.

The results shown in the attached tables were noted at given intervals of time and were arrived at by comparing the growth in the particular agar tube with that in the control tube. Cultures showing growth scantier than that in the control tube were considered as showing inhibition of growth and so marked in the tables.

It will be noticed that my figures indicating the titer of various oils do not agree with those of Walker and Sweeney. I prefer to give as a titer the quantity of the substance added to the culture medium rather than to give the final dilution of the drug in question, for the reason that it is impossible to estimate the exact amount of drug which comes into action when solid media are used and the culture is growing on the surface only. It is reasonable to assume that a quantity smaller than the one corresponding to the amount of the final dilution comes into action at a time under such conditions. This circumstance may be considered a disadvantage; on the other hand, there is a fairly even distribution and, so to speak, fixation of those drugs which in liquid media have the tendency to gather either on the surface or at the bottom of the medication tubes, or to precipitate out of solution. Moreover, the storage effect comes into action under these circumstances. The drug stored and preserved in the solid medium is less apt to undergo such changes (hydrolysis) as take place rather rapidly in high aqueous dilutions. The drug is given off from under the surface in as concentrated a solution as its solubility in water permits and is taken up by the growing cultures in as large an amount as its solubility in water and fats allows.

Furthermore, it was the purpose of these investigations to ascertain the fundamental principles of the direct action of various drugs on acid-fast bacteria rather than to set their definite and constant antiseptic values or indices. For the same reason, as will be noticed, the final dilutions in the culture media, of the substances tested, were made at rather large and irregular quantitative intervals.

This experiment (Table 1) tends to show that chaulmoogra oil has a considerable inhibiting power over *B. tuberculosis* and that the growth-inhibiting action is specific; that is to say, the chaulmoogra inhibits the growth of *B. tuberculosis* in high dilutions while liquid paraffin and olive oil do not prevent the growth of this microbe. Non-acid-fast bacteria are not inhibited by

concentration fifty times stronger than the limit of complete specific inhibition. Cod-liver oil appears to exhibit no inhibition toward *B. tuberculosis* in a dilution 1:100, while it inhibits cholera and *Staphylococcus* completely, and *B. typhosus* partially, in a dilution of the same strength.

Comparing the growth-inhibiting effect of different oils obtained from plants related to *Taraktogenos kurzii* King with each other and with the effect of true chaulmoogra this experiment (Table 2) shows that the oil of *Hydnocarpus alcalae* C. de Candolle, a Philippine product, gives as high antiseptic value as does chaulmoogra from India, while the growth-inhibiting power of *H. wightiana* Blume is still greater; that of *H. subfalcata* Merrill is little less than that of chaulmoogra, *H. venenata* Gaertner comes next, and *Gynocardia odorata* R. Brown shows practically no effect.[3]

It is not claimed that the values given in Table 2 are absolute, but they were constant with the same samples of oils. The quantitative differences in the growth-inhibiting power of these oils suggest a comparative study of these results and those obtained in the therapy of leprosy. Furthermore, this experiment brings out a point which seems to be of great interest. It can be seen from Table 2 that all of the oils in question, with the exception of *Gynocardia odorata,* show more or less a growth-inhibiting effect. Some years ago Brill[4] conducted a chemical study of chaulmoogra and related Philippine oils and came to the conclusion that all of them, with the exception of *G. odorata,* contain in various degrees the acids peculiar to chaulmoogra. On the other hand, Brill found other substances such as glucosides to be present in all of the oils, including *G. odorata.* From these findings he concluded that oils other than true chaulmoogra, with the exception of *G. odorata,* should have a similar therapeutic effect if the curative value of chaulmoogra is due to the presence of the peculiar acids. On the other hand, if the therapeutic effect of chaulmoogra is due to substances other than the acids, *G. odorata* should be just as valuable a drug as chaulmoogra. My bacteriologic observations are in agreement with the chemical findings of Brill, whose findings confirm those made previously by Power.

It is further evident from this table that the growth-inhibiting activity of these oils is specific.

[3] The hydnocarpus oils were kindly furnished by Dr. G. A. Perkins. See the paper by G. A. Perkins and A. O. Cruz, postea, page 543.

[4] Philip. Journ. Sci. § A 11 (1916) 75.

In order to make Table 3 intelligible, the method of preparation of the various soaps used in these experiments is taken from a paper by G. A. Perkins,[5] whose preparations I used.

Sodium gynocardate A. This is the derivative of chaulmoogra oil used for subcutaneous and intravenous injection since 1917 by Sir Leonard Rogers.

Sodium gynocardate S. This preparation was made in the same manner as sodium gynocardate A, except that the total fatty acids instead of the crystallized acids were employed.

Sodium gynocardate D. Differs from sodium gynocardate S only in that the fatty acids have been purified by distillation in vacuum.

The sodium morrhuate was prepared by Rogers's method. This consists in making the sodium soap of cod-liver oil and extracting with ether to remove irritating substances.

The results of experiments tabulated in Table 3 confirm the findings of Walker and Sweeney in their Table VII. It shows that sodium gynocardate S, a soap made of the total fatty acids of chaulmoogra oil, gives the highest antiseptic value; sodium gynocardate D (distillate) is next strongest, and sodium gynocardate A (Rogers) is not so strong as the other two soaps mentioned. Due probably to different technic, the differences in the effect of the various preparations are not so pronounced as in the experiments of Walker and Sweeney, but they are distinct.

The soaps made from isolated acids of chaulmoogra oil, [5] that is, sodium chaulmoograte and sodium hydnocarpate, show lower value than do the gynocardates, the hydnocarpate value being at least twenty times that of the chaulmoograte.

CONCLUSIONS

1. Chaulmoogra oil and its derivatives exert a pronounced growth-inhibiting action on *Bacillus tuberculosis* in vitro.

2. This inhibition is specific; that is to say, it is noticeable in dilutions of the oil in which no inhibition of non-acid-fast bacilli can be discerned.

3. Oils obtained from plants related to *Taraktogenos kurzii* have a property similar to that of chaulmoogra oil with regard to *Bacillus tuberculosis*. *Hydnocarpus wightiana, H. alcalae, H. subfalcata,* and *H. venenata,* all containing the optically active acids, show antiseptic power in vitro, the strength of the various

[5] For details see Philip. Journ. Sci. 21 (1922) 1–15.

oils decreasing in the order mentioned. Oil derived from *Gynocardia odorata,* a plant systematically closely related to *Taraktogenos kurzii,* proved to be inactive in our experiments. It lacks the optically active fatty acids.

4. The growth-inhibiting strength of the sodium salts of chaulmoogra oil acids appears to vary, in as much as the soap made from the total fatty acids inhibits the growth of *Bacillus tuberculosis* to a higher degree than does that made of a fraction of the acids.

5. A sodium salt prepared from isolated hydnocarpic acid approaches closely in strength the soap of total fatty acids, while the sodium salt of chaulmoogric acid is far below the soap of hydnocarpic acids as far as the growth-inhibiting effect is concerned.

The following abbreviations are used in Tables 1, 2, and 3:

$\frac{-}{-}$, no growth in two and four weeks.

$\frac{-}{+}$ inh, no growth in two weeks; growth in four weeks less than controls.

$\frac{+\text{ inh}}{+\text{ inh}}$, growth in two and four weeks scantier than controls.

+, growth as good as controls.

$\frac{+}{+}$, growth in two and four weeks as good as controls.

0, not tested.

—, no growth.

+ inh, inhibition growth scantier than controls.

$\frac{+\text{ inh}}{+\text{ ,}}$ growth scantier than controls in two weeks; as good as controls in four weeks.

$\frac{-}{+}$ m inh, growth poorer than in sodium gynocardate A culture tube.

$\frac{-}{+}$ v. m inh, growth poorer than in sodium gynocardate D culture tube.

TABLE 1.—*Growth-inhibiting effect of chaulmoogra oil as compared with inert oils.*

[Symbols are explained in the last paragraph of text.]

Name.	Cubic centimeters of oil added to one slant of agar.								
	Bacillus tuberculosis.						Typhoid.	Cholera.	Staphylococcus.
	0.1	0.05	0.01	0.005	0.001	0.0005	0.1	0.1	0.1
Chaulmoogra oil, India	—	—	—	—	—	+ inh	+	+	+
	—	—	—	—	+ inh	+ inh			
Chaulmoogra oil, Japan	—	—	—	—	+	+	+	+	+
	—	—	—	+ inh	+	+			
Paraffin liquid	+	+	+	0	0	0	+	+	+
	+	+	+						
Olive oil	+	+	+	0	0	0	+	+	+
	+	+	+						
Cod-liver oil	+	+	+	+	+	+	+ inh	—	—
	+	+	+	+	+	+			

TABLE 2.—*Comparison of growth-inhibiting effect of oils obtained from plants closely related to Taraktogenos kurzii.*

[Symbols are explained in the last paragraph of text.]

Name.	Cubic centimeters of oil added to one slant of agar.								
	Bacillus tuberculosis.						Typhoid.	Cholera.	Staphylococcus.
	0.1	0.05	0.01	0.005	0.001	0.0005	0.1	0.1	0.1
Hydnocarpus wightiana	—	—	—	—	—	+ inh	+	+	+
	—	—	—	—	—	+			
Hydnocarpus venenata; Brill[a]	—	—	—	—	+	+	+	+	+
	—	—	+ inh	+ inh	+	+			
Hydnocarpus subfalcata; Perkins	—	—	—	—	+	+	+	+	+
	—	—	+ inh	+ inh	+	+			
Hydnocarpus alcalae	—	—	—	—	+	+	+	+	+
	—	—	—	—	+ inh	+			
Gynocardia odorata	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+			

[a] Sample several years old.

TABLE 3.—*Comparison of growth-inhibiting effect of chaulmoogra soaps prepared from various fractions and isolated acids.*

[Symbols are explained in the last paragraph of text.]

Name.	Concentration.	Cubic centimeters of soap solution added to one slant of agar *B. tuberculosis*.							
		0.1	0.05	0.01	0.005	0.001	0.0005	0.0001	0.00005
	Per cent.								
Sodium gynocardate A No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ inh	+	+		
Sodium gynocardate D No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ m inh	+	+		
Sodium gynocardate S No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ v. m inh	+	+		
Sodium hydnocarpate C. P	3	−	−	−	+ inh	+	+	0	0
		−	−	+	+	+	+		
Sodium chaulmoograte C. P	3	+ inh	+ inh	+ inh	+	+	+	0	0
		+	+	+	+	+	+		
Sodium morrhuate	3	−	+	+	+	+	+	0	0
		+	+	+	+	+	+		
Green soap	1	+	+	+	+	+	+	0	0
		+	+	+	+	+	+		

A COMPARATIVE ANALYTICAL STUDY OF VARIOUS OILS IN THE CHAULMOOGRA GROUP [1]

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ONE PLATE

Although there is no longer room for doubt that chaulmoogra oil and certain hydnocarpus oils contain substances which are valuable in the treatment of leprosy, the relative value of the various oils and of the substances which they contain still remains unknown. The discovery of chaulmoogric and hydnocarpic acids by Power,[2] the successful clinical use of pure esters of these acids by Hollmann, Dean, and McDonald,[3] and the bacteriological studies of Walker and Sweeney,[4] have given a scientific basis to chaulmoogra therapy in a qualitative and preliminary way; but much remains to be done before the bacteriologist and clinician can be given a satisfactory chemical description of the chaulmoogra group of oils.

The information contained in Table 1 summarizes practically all of the analytical results on the chaulmoogra group which have hitherto been published by various investigators, although much more work has been done than one would infer from a glance at this table. Compared to many tables of oil "constants" this table may appear complete, but an examination of the literature represented discloses three deficiencies which are very

[1] Published by permission of the Director of Health and the Philippine Leprosy Research Board. Submitted for publication June 6, 1923.

[2] Power, F. B., and Gornall, F. H., Journ. Chem. Soc. 85 (1904) 838; Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. 87 (1905) 884.

[3] Hollmann, H. T., and Dean, A. L., Journ. Cutan. Dis. 37 (1919) 375; McDonald, J. T., Journ. Am. Med. Assoc. 75 (1920) 1485.

[4] Walker, E. L., and Sweeney, M. A., Journ. Infect. Dis. 26 (1920) 238.

important from the therapeutic standpoint, namely: The chemical work has been confined to less than half of the oils which, from botanical and other reasons, may be confidently placed in the chaulmoogra group. The various constituents have not been determined quantitatively. Unknown constituents are present in probably all of the oils and may form a large part of certain oils.

One of the aims of the chemical laboratory at Culion Leper Colony is to take a part in remedying these deficiencies in our knowledge of chaulmoogra, and it is hoped that the present study will be found a step in that direction. Our field was necessarily limited to oils which we were able to obtain and the following objectives were held in mind:

1. Establishment of criteria for the recognition of each oil if possible, and for the detection of adulteration.

2. Sufficient separation of each oil into its constituents as would enable its evaluation as a potential source of hydnocarpic, chaulmoogric, or some unknown fatty acid in case any of these should be found by clinicians particularly valuable therapeutically.

3. Determination of economically important considerations, such as yield of oil, keeping qualities of seeds, etc.

The study has included work on a few commercial oils, but has been chiefly devoted to samples obtained in the laboratory from seeds of known species. Ten species were included: *Taraktogenos kurzii*, seven species of *Hydnocarpus*, *Pangium edule*, and *Gynocardia odorata*. *Taraktogenos kurzii* is the true chaulmoogra, but the genus *Hydnocarpus* is very closely allied both botanically and chemically to the genus *Taraktogenos*. *Hydnocarpus* oils are, therefore, included in the chaulmoogra group and some of them may be as effective as or possibly more effective against leprosy than chaulmoogra oil. Three of the *Hydnocarpus* species studied are found only in the Philippines, two are Indian species, one is from Borneo, and one from Indo-China. *Gynocardia odorata* and probably *Pangium edule* cannot be classed in the chaulmoogra group, but were included in the study to clear up certain errors and discrepancies existing in the literature concerning their relation to this group. Only three of these species are additional to the list in Table 1, but we hope to be able to obtain other species and extend the work.

DISCUSSION OF SEEDS USED [5]

GYNOCARDIA ODORATA R. BROWN

This seed is found in the forests of Assam, where it is even now confused with *Taraktogenos kurzii*. Although Power and Barrowcliff found the *Gynocardia* oil to be entirely different from *Taraktogenos* oil (see Table 1), this oil was included in our study because of the contradictory report of Brill and Williams [6] on a sample of *"Gynocardia odorata"* purchased through the Department of Agriculture, Assam. We have not only confirmed Power's results, but have, like Brill and Williams, found it difficult to obtain genuine *Gynocardia* seeds from Assam. This is surprising in view of the easy distinction pointed out by Muir.[7] The radical of the *Gynocardia* seed is lateral, while that of the *Taraktogenos* and *Hydnocarpus* is terminal.

The *Gynocardia* seeds used in this study were purchased from a Calcutta firm.

HYDNOCARPUS ALCALAE C. DE CANDOLLE

This is the largest *Hydnocarpus* seed known to us and is the only Philippine species which we have succeeded in obtaining in commercial quantities. Our supply has been obtained from the Provincial Treasurer of Albay (samples *A* and *C*), and from ex-Governor Timoteo Alcalá of that province (sample *B*). The local names are *dudóa* and *dudu-dudu*. The fruit is about 20 centimeters long and 10 to 12 centimeters in diameter. The seeds are about 3 centimeters long. January and February seem to be the best months for collecting this fruit.

HYDNOCARPUS ANTHELMINTHICA PIERRE

This well-known seed, *lukrabao* (*lukrabo*), is found extensively in Indo-China. Our samples were purchased from a Bangkok firm.

[5] Botanical and economic data on *Gynocardia odorata*, *Hydnocarpus anthelminthica*, *H. castanea* (of which we have no specimens for this study), and *Taraktogenos kurzii* have been reported by J. F. Rock in The Chaulmoogra Tree and Related Species, Bull. U. S. Dept. Agr. 1057 (1922).

[6] Brill, H. C., and Williams, R. R., Philip. Journ. Sci. § A 12 (1917) 211.

[7] Muir, E., Handbook on Leprosy, Orissa Mission Press, Cuttack, India (1921) 39.

TABLE 1.—*Physical and chemical data already available on chaulmoogra and related oils.*

Species.	Yield of oil from seeds.	Specific gravity.	Refractive index.	Melting point.	Specific rotatory power.	Iodine value.	Saponification value.	Acid value.
	P. ct.			°C			*mg. KOH.*	*mg. KOH.*
Gynocardia odorata (pressed oil)[a]	19.5	0.925 at 25°		20	Nil.	152.8	197.0	4.9
Hydnocarpus alcalae[b]	40.8	0.9502 at 30°	1.4770	32	+49.60	93.1	188.9	21.8
Hydnocarpus alpina[c]		0.898 at 100°	1.4709 at 40°	22–26	+49.5	84	207	0.35
Hydnocarpus anthelminthica (pressed oil)[d,e]	16.3	0.953 at 25°	1.473	24–25	+52.5	86.4	212.0	7.5
Hydnocarpus venenata (pressed oil)[f]	23.3	0.9475 at 30°	1.4770 at 30°	19–20	+52.03	99.1	200.3	24.7
Hydnocarpus wightiana (pressed oil)[d,g]	32.4	0.958 at 25°		22–23	+57.7	101.3	207.0	3.8
Oncoba echinata (extracted oil)[h]	47	0.898 100/15.5		35–45	+48.8	99.7	192.4	4.5
Pangium edule[h]	6.1	0.9049 (0.9092)	1.4665	2	+ 4.28 (20.65)	113.1	190.3	2.9
Taraktogenos kurzii (pressed oil)[i,e]	30.9	0.951 at 25°	1.476	22–23	+52.0	103.2	213.0	23.9

Species.	Chaulmoogric acid.	Hydnocarpic acid.	Other constituents.	Fatty acids, melting point.	Fatty acids, specific rotatory power.
				°C	
Gynocardia odorata (pressed oil)[a]	None	None	Gynocardin, linolic, palmitic, linolenic oleic.		None.
Hydnocarpus alcalae[b]	Approximately 90 per cent	None?	Palmitic, oleic	59	+53.65
Hydnocarpus alpina[c]	Indicated	Indicated			
Hydnocarpus anthelminthica (pressed oil)[b,e]	Present	Present	Glucoside, oleic, palmitic	42–43	+53.6

Hydnocarpus venenata (pressed oil) [f]	do	do	Glucoside	43	+60.96
Hydnocarpus wightiana (pressed oil) [d,g]	do	do	Unknown unsaturated acid	41–44	+60.4
Oncoba echinata (extracted oil) [b]	84.5 per cent		No palmitic, liquid acids 12 per cent		+52.5
Pangium edule [b]	Indicated	Indicated	Unsap. 1.5 per cent, gynocardin, palmitic	18	+ 3.49 (4.72)
Taraktogenos kurzii (pressed oil) [i,e]	Present	Present	Glucoside, palmitic acid	44–45	+52.6

[a] Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. **87** (1905) 896. The extracted oil was very similar except that the yield was 27.2 per cent.
[b] Brill, H. C., Philip. Journ. Sci. § A **12** (1917) 37.
[c] Wolf, H. H., de, and Koldewijn, H. B, Pharm. Weekblad **49** (1912) 1049, as abstracted in Chem. Centralblatt **84** (1913) 31.
[d] Hollmann, H. T., and Dean, A. L., Journ. Cutan. Dis. **37** (1919) 375; McDonald, J. T., Journ. Am. Med. Assoc. **75** (1920) 1485.
[e] Data on the extracted oil are very similar.
[f] Brill, H. C., Philip. Journ. Sci. § A **11** (1916) 75.
[g] Data on the extracted oil are very similar, except the yield, 41.2 per cent.
[h] Goulding, E., and Akers, N. C., Proc. Chem. Soc. **29** (1913) 197.
[i] Power, F. B., and Gornall, F. H., Journ. Chem. Soc. **85** (1904) 838; Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. **87** (1905) 884.

HYDNOCARPUS HUTCHINSONII MERRILL

The following description of *Hydnocarpus hutchinsonii* is quoted from Bureau of Science press bulletin No. 105, January 27, 1922:

Found in the eastern part of Mindanao, on Basilan Island, in the Sulu Archipelago, and in British North Borneo. The tree grows to a height of 25 meters but is usually not over 15 meters in height. Most of the trees have a diameter of 10 to 15 cm, one meter from the ground, but the larger specimens attain a diameter of 35 cm. The bark is rather smooth, often stippled. It is found in the primary forest, but the largest specimens are found in the bog or cut-over forest. It is found from sea level to at least 600 meters altitude.

Leaves.—The leaves are oblong, smooth edged, 15 to 30 cm long, 5 to 12 cm wide, the base distinctly inequilateral, usually rounded or obtuse on the broader side, and often acute on the narrower side, the apex rather abruptly and distinctly pointed. The upper surface is dark green, shining, smooth, the lower surface brownish, distinctly showing reticulated veins. The lateral veins 12 to 14 on each side of the midrib, prominent, curved, anastomosing close to the margin. Petioles usually about 1 cm long.

Flowers.—Small, yellow flowers about 1 cm long.

Fruits.—The tree fruits in July or August although a few fruits are found at other times of the year. The fruit is almost spherical, from 7 to 10 cm in diameter, with a short stocky stem. The shell (pericarp) is rather thin and brittle when dry, with a smooth surface. The fruit contains from 20 to 45 seeds in a small amount of pulp. The fruit is a light brownish green on the tree, turning to a brown when dried. The appearance roughly resembles that of an orange.

Seeds.—The seeds are packed tightly in the fruit and hence have a rounded polygonal shape not over 2.5 cm long. When dried, part of the seed is smooth with slight ridges, and part covered with tiny warts. The shell of the seed is thin, brittle, and brown when ripe. The kernel is solid, white, oily, odorless, and rather tasteless.

Local names.—The tree is known by the people of various districts as follows: Basilan—*mansaloka, mangasalokag;* Zamboanga Peninsula—*kamupang, dinagas, tioto, sugalingayan;* Lanao—*bagarbas, kalumpang;* Jolo—*kaumpang, kamupang.*

Collection of fruit.—The fruit falls about July or August and should be collected at that time, and the seeds removed and dried immediately to prevent molding.

Dr. H. I. Cole, of the Bureau of Science, in a recent extensive survey found a large supply of these seeds in Mindanao forests, but the difficulty in collecting them and the relatively high price of Moro labor have prevented us from obtaining a regular supply. The samples used in this study were collected at Basilan, Zamboanga, by Doctor Cole with the coöperation of the Bureau of Forestry.

HYDNOCARPUS SUBFALCATA MERRILL

Quoting from the same bulletin as before:

This species is found in Zambales, Pangasinan, and Cagayan, Luzon; Sibuyan, Samar, and Mindanao (Surigao). It bears a green fruit 1 to 4 cm in diameter containing from 2 to 8 small seeds. Its local names are *mala usa, binting dalaga, amitan* (Ibn.), *apanang* (C. Bis.), *dalinias* (Sbl.), *damol* (S. L. Bis.), *lagtang* (P. Bis.), *ñgeret* (Tag.), pai (Pang.), *putian* (Sbl.).

A small supply of *H. subfalcata* seeds has been obtained from the Provincial Treasurer of Zambales. The fruit ripens in May.

HYDNOCARPUS VENENATA GAERTNER

The seeds of this species are similar to those of *Hydnocarpus wightiana* (see the following species) but are smaller, and have seven veins in the cotyledon instead of five. Our samples were obtained from Ceylon, through the Superintendent of the Peradeniya Gardens. This species is said to be found also in East and West Deccan, and in Burma.

HYDNOCARPUS WIGHTIANA BLUME

This species appears to be available in larger quantities than any of the other species of the chaulmoogra group. The seed is about 2 centimeters long with longitudinal grooves, and a knob at the end. It is found in southwestern India and shipped in commercial quantities from Ernakulam. The Ernakulam Trading Co. also presses out and exports the oil.

HYDNOCARPUS WOODII MERRILL

Our sample of this species was collected by Mr. A. D. E. Elmer, in British North Borneo, near Sandakan. The seed is similar to that of *Hydnocarpus hutchinsonii.*

PANGIUM EDULE REINWARDT

This seed has been examined by Brill (see Table 1 and references), who concluded that it contained chaulmoogric or hydnocarpic acids. Our results, as will be seen, are not in accord with this conclusion. The species is widely distributed in the Philippines and neighboring islands. Our samples were obtained from Zamboanga.

TARAKTOGENOS KURZII KING

This seed, the official chaulmoogra, is quite different from *Hydnocarpus wightiana* in external appearance, being smooth

and somewhat larger. The interior structure of the two seeds is very similar; but, judging from our experience, *Taraktogenos kurzii* becomes rancid rapidly, while *Hydnocarpus wightiana* keeps well for years. Most of our supply of seed was obtained through a Rangoon firm, probably from Chindwin Valley. Other sources are Assam and Bengal. On account of the poor keeping qualities of the seed, shipments from Chittagong (the most important chaulmoogra oil center) are made chiefly in the form of oil.

EXTRACTION OF THE OILS

The data on yield of oil, amount of shell, etc., of the ten species are collected in Table 2, the items being as follows:

Sample.—The samples are described in the previous section. Usually a 2,000-gram sample was taken, which gave sufficient oil for the distillation test. A larger sample of *Pangium edule* was necessary.

Estimated age.—The age alone does not determine the condition of the sample. Almost all of the samples were sundried immediately after collection, but in many cases this was not done with sufficient thoroughness. In the dry conditon all of the seeds seem to be quite stable.

Approximate weight.—Usually twenty representative seeds were chosen for this determination. Considerable variation in size will be noted. The large seeds of the chaulmoogra group are *Hydnocarpus alcalae* and *H. woodii.* Of these the former has much the larger fruit.

Shells of first- and second-grade seeds.—The basis of grading is explained in the next paragraph. The weights of shells in each grade are given because they show approximately the relative numbers of first- and second-grade seeds in the sample.

First- and second-grade kernels.—Kernels which showed no gross destruction by mold were considered first grade. Probably all of the kernels would have been of this grade if they had been properly dried as soon as they became ripe. Such kernels showed in general only slight signs of aging, but *Taraktogenos kurzii* kernels show a marked tendency to darken and acquire a rancid odor, even though quite dry. *Hydnocarpus wightiana* on the other hand, retains a fresh odor, taste, and appearance for many months if kept fairly dry.

The second-grade kernels were often almost totally destroyed by mold, so that low yields of oil were obtained in cases where a large proportion of the seeds had molded.

Moisture.—The figures for moisture were obtained incidentally while drying the ground kernels for extraction.

Solvent.—The dry ground kernels were extracted in an apparatus of the Soxhlet type. Because the work was done in different laboratories the solvent was varied to suit the apparatus used.

First- and second-grade oil.—The oil from the first-grade kernels, rather than the total oil, was chosen for the analytical work because of the extensive decomposition which had occurred in the second-grade oil. The free fatty acid figures in Table 3 show the comparatively well-preserved character of the first-grade oil.

The low oil yield occasioned by imperfect drying is well shown in the figures for *Hydnocarpus alcalae, B.*

CHARACTERISTICS OF THE OILS

General.—Table 3 shows the results of some of the usual physical and chemical tests on the oils studied. All of the determinations made have value for certain purposes, but the optical rotation is obviously the outstanding characteristic of the chaulmoogra group. The iodine number and the freezing point of the fatty acids afford in certain cases means of distinguishing one member of the group from others, and the acidity is an index of the degree of preservation. Conclusions as to the variations in each characteristic as well as descriptions of the methods used follow under the appropriate headings.

All of the oils were liquid at room temperature (30° C.), but one rancid commercial chaulmoogra oil (*Taraktogenos kurzii, G*) had a large proportion of solid deposit. The color of the pressed oils varied, according to the care used in manufacture, from a yellow similar to that of good olive oil (*Taraktogenos kurzii, G*) to a reddish brown (*Taraktogenos kurzii, G*). The first-grade extracted oils had a color similar to the darker pressed oils and the second-grade extracted oils were very dark.

Samples.—The samples designated as first-grade and second-grade were the extracted oils obtained as shown in Table 1.

Hydnocarpus subfalcata, B, was a cold pressed oil obtained from first-grade *Hydnocarpus subfalcata* kernels.

Hydnocarpus wightiana, B and *C,* were commercial pressed oils obtained from Calcutta dealers.

Taraktogenos kurzii, B to *N,* were commercial oils sold as chaulmoogra by various dealers. Of these, *N* is obviously adulterated, and *C* is suspiciously like *Hydnocarpus wightiana* in

TABLE 2.—*Extraction of the oils.*

[All percentages are based on the total original sample.]

Sample.	Estimated age.	Approximate weight of one seed.	Shells of first-grade seeds.	Shells of second-grade seeds.	First-grade kernels.	Second-grade kernels.	Moisture.	Solvent.	First-grade oil.	Second-grade oil.	Total oil.
	Months.	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Gynocardia odorata	10	1.1	26.5	2.0	68.0	2.0	----------	Benzene	26.0	----------	26.0
Hydnocarpus alcalae:											
A	6	2.2	----------	----------	32.6	32.6	3.8	Toluene	22.7	16.9	39.6
B	2	4.2	18.6	9.5	52.6	7.8	17.8	do	18.0	2.6	20.6
C	12	3.3	13.5	22.0	32.0	31.8	2.8	Benzene	18.9	19.5	38.4
Hydnocarpus anthelminthica	11	1.4	66.0	None.	30.2	None.	1.7	do	12.2	None.	12.2
Hydnocarpus hutchinsonii	4	1.6	18.6	22.2	45.7	7.6	4.5	Toluene	17.8	5.1	22.9
Hydnocarpus subfalcata	8	0.7	21.5	13.3	48.6	15.0	2.0	Benzene	27.5	8.4	35.9
Hydnocarpus venenata	5	0.3	18.5	32.0	38.5	11.0	2.3	do	22.6	7.0	29.6
Hydnocarpus wightiana	14	1.2	33.5	2.0	60.5	4.0	2.4	do	33.3	2.9	41.2
Hydnocarpus woodii:											
A	12	----------	----------	----------	36.5	4.4	----------	Ether	8.8	2.2	11.0
B	12	4.2	56.0	None.	44.0	None.	----------	do	20.6	None.	20.6
Pangium edule:											
A	2	14.4	30.4	20.3	30.4	14.7	13.6	Toluene	5.7	2.4	8.1
B	2	11.5	21.8	25.0	23.6	19.0	3.6	Benzene	7.3	8.1	15.4
Taraktogenos kurzii	8	1.9	27.2	15.5	45.9	10.4	2.0	do	23.5	5.3	28.8

rotation and freezing point of fatty acids. Sample *G* is typical of the commonly found rancid commercial chaulmoogra oil which is dark brown when melted but has a large amount of light semisolid deposit even at 30° C. Many physicians and patients accustomed to this product, obtained from partly rotten seeds, look with suspicion on the more carefully prepared oils. Samples *H, I,* and *L* were obtained from P. K. Sen, Chittagong, India. We were informed from reliable sources at the time that only selected *Taraktogenos kurzii* seeds were used by this manufacturer, and that the oil was cold pressed. These oils were of much better quality than the crude oils above mentioned, having less color, acidity, and odor and practically no sediment at 30° C. The most carefully manufactured oils which we were able to obtain were *D, E,* and *J,* from Shiongi & Co., Osaka, Japan. These samples were very light in color, clear, and almost odorless, but it is difficult to decide from the data whether they are *Taraktogenos kurzii* or *Hydnocarpus wightiana.*

Specific gravity.—The determination of specific gravity was made with a hydrometer at 30° C. Different samples of the oil from the same species show expected variations on account of varied acidity, difference in treatment, etc. The oils of the chaulmoogra group all show a high specific gravity (0.943 to 0.956), matched by only a few other oils.

Due to its variation in different samples of the same oil, the specific gravity is of no value in determining the species of an unknown oil, but a specific gravity below 0.940 in an alleged chaulmoogra or hydnocarpus oil would indicate adulteration.

Refractive index.—An Abbe refractometer was used, either at 30° C. or within one or two degrees of this temperature. In the latter case a correction of 0.00038 per degree was applied.

The chaulmoogra group shows a high refractive index, but not sufficiently high to be distinctive, and there seems to be no significant variation within the group.

Freezing point.—This simple though rather inexact determination was made to obtain a relative idea of the tendency to solidity exhibited by the various oils. The sample was cooled in a test tube and the temperature at which it became semisolid was noted. (See also freezing point of fatty acids.)

Rotation.—The optical rotation was determined in a quartz wedge saccharimeter, using white light filtered through dichromate. Usually the sample was placed in a 4-centimeter tube. All results are expressed in angular degrees per decimeter, as is customary for optically active liquids. To compare these

figures with the specific rotatory power figures given in Table 1, the latter are to be multiplied by the specific gravity.

Optical rotation is unquestionably the most characteristic simple property of the chaulmoogra group. Many other oils show some rotation, but none outside of the chaulmoogra group are known with a rotation as high as 45° to 50°. Of the oils studied *Gynocardia odorata,* with no rotation, is definitely outside of the chaulmoogric group, but *Pangium edule* shows a rotation of 2.8° to 16.9°. The composition of this oil is discussed on another page. The other oils, definitely in the chaulmoogra group, have the rather narrow range of 43.5° to 51.6°. *Taraktogenos kurzii,* counting only the authenticated samples, has a range of 43.5° to 46.3°. Our samples of *Hydnocarpus anthelminthica, H. hutchinsonii, H. venenata,* and *H. woodii* also fall within these limits, but *H. alcalae, H. subfalcata,* and *H. wightiana* give definitely higher values. The inference is that the last-mentioned three oils contain more chaulmoogric, hydnocarpic, or similar acids than true chaulmoogra and are, therefore, slightly superior to it for medicinal use. In our present state of knowledge, both chemical and clinical, these cannot be considered as established facts, but only as suggestive indications.

The difference in rotation between the two samples of *Hydnocarpus subfalcata* is possibly due to the fact that sample *A* is extracted, while sample *B* is pressed.

Iodine number.—The Hanus method was used, one hour being found a convenient time to insure complete absorption. The figure given in each case is the average of two closely agreeing determinations.

The iodine number is of some value in distinguishing between the different oils of the chaulmoogra group, as may be seen in Table 3. The authentic chaulmoogra samples show an iodine number very close to 100, and *Hydnocarpus wightiana* is the only other in the chaulmoogra group as high as this. *Hydnocarpus alcalae* is not much different, but the rest seem to be definitely lower.

A high iodine number indicates the absence of saturated fatty acids and the presence of acids less saturated than those in the chaulmoogric series; the former are probably relatively inactive, but it remains for clinicians to discover whether the latter are beneficial or harmful. If, as is indicated by Power's

work,[8] some of the strongly unsaturated acids contain the chaulmoogric grouping as well as a double bond, these acids would be expected to be very active, but not necessarily in a beneficial way.

Saponification number.—This was determined in the usual manner, and is expressed in milligrams of potassium hydroxide per gram of oil. It is about 200 in all of the oils studied.

Acidity.—As none of the seeds were strictly fresh a slight rancidity and corresponding acidity were to be expected. The *Taraktogenos kurzii, A* (first grade) oil showed surprisingly little acidity, although the seeds were more rancid than those of *Hydnocarpus wightiana.* Commercial chaulmoogra oil is usually very rancid, and only a small proportion of oil as good in this respect as *D, E,* and *J* is to be found on the market.

Freezing point of the fatty acids.—This was determined in the same manner as the freezing point of the oil, and is a simplified titer test. Only the insoluble acids were used, the soluble acids being negligible. The freezing point was quite sharp in most cases and is, therefore, more characteristic than the freezing point of the oil.

The authentic *Taraktogenos kurzii* samples gave, in this test, the low figures of 22° to 29° for pressed oils and 32° for the extracted oil. This distinguishes them, though not very sharply, from all the other authentic chaulmoogra-group samples, which gave 34° to 39° for the pressed oils and 36° to 55° for the extracted. *Hydnocarpus alcalae* stands entirely alone, giving a value (55°) 8° higher than that of the nearest competitor, *H. venenata* (47°). The remaining five oils range only between 34° and 43°.

The connection between this determination and composition can be shown better later in the paper, when the freezing points of various fractions are discussed.

Specific rotatory power of the fatty acids.—This value was found by "polarizing" a xylene solution of the fatty acids, using 2 grams or 5 grams in 50 mils. The readings were converted to angular degrees, and divided, as is usual for substances in solution, by the concentration and the length of the tube in decimeters.

Due to the difficulties in using high concentrations, especially because of the color, these values were not as accurately deter-

[8] Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. 87 (1905) 891.

mined as were the rotations of the oils themselves, but they serve to show that the variation of optical rotation in the different oils is really due to differences in the composition of the fatty acid fraction and not to differences in the manner of its combination with glycerol or to the presence of some other optically active constituent. This is especially interesting in the case of *Pangium edule*, which will be discussed in the next section.

FRACTIONATION OF THE ETHYL ESTERS

In the preceding section certain tests have been shown to be valuable in distinguishing the chaulmoogra group of oils, in differentiating to some extent between the members of this group, and, in connection with clinical data, in judging roughly the therapeutic value of a given oil. These tests are not strictly analytical, however, and taken alone do not determine, quantitatively or qualitatively, any one constituent. The next step, reported in this section, was to effect a partial separation of the mixed fatty acids. A complete separation is such a difficult matter that it has not been attempted in this study, but the work on *Taraktogenos kurzii* and *Hydnocarpus wightiana* is being extended with the expectation of reporting the approximate quantitative composition of these in a later paper.

The most successful general method of separating fatty acids uses the difference in boiling point of the esters to separate acids of different numbers of carbon atoms, and the difference in solubility of certain salts or addition products to separate acids with differing degrees of unsaturation. In the case of commercial chaulmoogra oils Dean and Wrenshall [9] have modified this method in that they prefer to distill the acids instead of the esters, and crystallize the acids instead of their salts. Their immediate object was to obtain pure chaulmoogric and hydnocarpic acids rather than to find the percentage composition of the oils used.

For the present study direct crystallization of the acids was adopted, as being more rapid and nearly as effective as crystallization of the salts. The ethyl esters were distilled, rather than the acids, being as easy to prepare, much easier to distill, and not subject to as much decomposition during distillation. In order to cover the ten samples in a reasonable time only one

[9] Dean, A. L., and Wrenshall, R., Journ. Am. Chem. Soc. 42 (1920) 2626.

distillation was made of each, and four out of the six fractions were examined, each of the four being given a single crystallization. The separations are incomplete, but data have been obtained which already have a comparative value and will have a quantitative value when the composition of any one of the oils becomes known.

DETAILS OF THE METHOD USED

A mixture of 500 grams of the oil, 750 mils of 95 per cent alcohol, and 20 mils of sulphuric acid (specific gravity, 1.84) was put in a round-bottom flask fitted with a reflux condenser and boiled vigorously for sixteen hours. The resulting crude ester mixture was washed with water, and then with dilute sodium hydroxide, making sure that a slight excess of sodium hydroxide remained after thorough shaking in the cold. The emulsion was broken up by heating, and the separated ester was thoroughly dried and weighed. The acidity of the dried ester mixture was then determined. (The weight should be at least 450 grams and the acidity not more than 0.2 per cent.)

Three hundred mils of the dried ester were distilled in vacuo in a standard Pyrex 500-mil Hempel distilling flask, the neck of which was filled with broken glass. Fractions of 50 mils each were collected. The temperature limits and pressure for each fraction were noted, and each was weighed.

The first, second, fifth, and sixth fractions were separately thoroughly saponified and the fatty acids set free. The freed acids from each were recrystallized from 200 mils of 80 per cent alcohol, cooling to about 15° C., and the filtrates again saponified and treated with acid. The crystals are designated (Tables 4, 5, 6, 7) by *a*, in addition to the appropriate fraction number, and the fatty acids (completely free from inorganic acid) from the alcoholic filtrates are designated by *b*.

The weight, freezing point, iodine number, and specific rotatory power in xylene of each fraction were recorded.

Fractions 3 and 4 of most of the oils were not tested, for the reason that they are intermediate fractions and the data gained do not appear worth the time consumed. The general tenor of the data on these fractions may be seen in Tables 6 and 7, where they are recorded for a few of the samples.

During the latter part of the work the pressure was regulated at 20 millimeters by an adjustable mercury trap.

TABLE 3.—*Characteristics of the oils.*

Sample.	Specific gravity $\frac{30\,°C.}{30\,°C.}$	Refractive index $n\,^{30}D.$	Freezing point, °C.	Rotation, 100 mm, 30 °/D.	Iodine number, Hanus.	Saponification number.	Acidity, as per cent oleic.	Fatty acids, freezing point, °C.	Fatty acid, specific rotatory power, $[\alpha]\,^{30}D.$
Gynocardia odorata, first grade	0.929	1.4743	4	0	160	198	2.7	20	0
Hydnocarpus alcalae, C:									
First grade	0.948	1.4763	24	48.3	94.0	202	6.7	55	40
Second grade							32.6		
Hydnocarpus anthelminthica, first grade	0.952	1.463	16	44.2	84.5	201	3.6	36	50
Hydnocarpus hutchinsonii:									
First grade	0.943	1.4743	23	44	83.5	199	5.3	43	50
Second grade			12		77.0	183	26	39	
Hydnocarpus subfalcata:									
A, first grade	0.951	1.4761	21	49.1	89.0	206	6.6	41	36
A, second grade							41		
B	0.956	1.4770	15	51.6	91.5	205	6.2	34	55
Hydnocarpus venenata:									
First grade	0.947	1.4769	20	46.4	90.7	191	1.2	47	49
Second grade							40.0		
Hydnocarpus wightiana:									
A, first grade	0.947	1.4763	11	51.2	97.0	207	6.7	40	54
A, second grade							27		
B	0.950	1.4772	13	50.1	99.1	204	6.3	39	54
C	0.948	1.4769	11	51.4	101	204	15.1	35	56
Hydnocarpus woodii, A, first grade		1.473	18	45.9	68.5	192	5.9	43	53
Pangium edule, B:									
First grade	0.925	1.472	7	16.9	78.5	200	6.9	18	17
Second grade		1.467	4	2.8	75.0	181	21	17	2

Taraktogenos kurzii:									
A, first grade	0.951	1.4771	9	43.5	104	215	3.4	32	43
A, second grade							74		
B	0.948	1.4769	9	45.1	105	199	14.8	36	50
C	0.948	1.4765	14	51.2	102	203	18.8	39	58
D	0.946	1.4753	20	47.9	96	203	5.5	32	52
E	0.946	1.4753	20	47.5	95	204	4.5	28	51
F	0.947	1.4763	10	46.7	104	197	13.0	21	51
G	0.948	1.4764	8	46.2	97	203	22.6	28	51
H	0.951	1.4767	9	45.9	102	198	13.8	29	49
I	0.949	1.4762	18	46.3	96	187	14.9	22	48
J				47.2			4.1		
K	0.952	1.4770	5	45.7	105	204	14.6	26	47
L	0.948	1.4768	5	45.1	104	205	12.6	23	48
M	0.950	1.4762	7	44.9	102	204	15.5	24	48
N				26			39		

CHARACTERISTICS OF THE FRACTIONS

The results of the tests described in the preceding section are recorded in Tables 4, 5, 6, 7, 8, and 9. Instead of discussing the tables separately it will be found more convenient to take up the data of all six tables, column by column.

Samples.—The lettering or other designation of the samples indicates their correspondence with the samples mentioned previously in this paper.

Hydnocarpus alcalae, A, was distilled into five instead of six fractions. The fourth and fifth fractions are tabulated with fractions 5 and 6, because they are the last two fractions. Fraction 4 is accordingly lacking for this sample.

Taraktogenos kurzii, D and *F,* have small final fractions because of accidental difficulty in washing the crude ester and consequent lack of ester for distillation.

Pressure.—No appreciable decomposition takes place at 20 millimeters. Lower pressures are disadvantageous from the point of view of fractionation. In the cases where the pressures are different from 20 millimeters a rough correction of 1° per millimeter may be applied to the temperatures.

Temperature.—The temperatures are not corrected for stem exposure. They indicate that between the first and last fractions satisfactory separation was obtained, but otherwise are not of much value. Variations due to small leaks and other experimental difficulties mask differences which may be characteristic of the individual oils. *Hydnocarpus alcalae, B,* however, shows the relative constancy of boiling point which agrees well with the later data.

Weight.—Approximately 50 mils were collected in each fraction, but there was some accidental variation, as is shown by the column of weights. The shortages in *Taraktogenos kurzii, D* and *F,* Tables 8 and 9, were caused by the inadvertent use of too little ester for distillation.

Fatty acids; weight.—The weight given in column *b* for any fraction shows the solubility of the fraction in 200 mils of cold 80 per cent alcohol. It was difficult to secure uniform deposition in all samples due to such factors as retention of filtrate, supersaturation, re-solution of crystals while filtering, etc. As solubility figures, therefore, these columns are not very accurate, but they are necessary in connection with later figures to show the relative proportions of subfractions *a* and *b.*

Freezing point.—This was taken as described on page 553, and is very valuable in indicating the amount of liquid acid

present or the purity of the sample in hydnocarpic or chaulmoogric acid.

The fractional crystallization was not sufficiently thorough to demonstrate liquid acids, except in the case of *Pangium edule*.

Hydnocarpic acid is found in column *a*, Tables 4 and 5. *Hydnocarpus alcalae* is unique in giving chaulmoogric acid in these fractions, as is shown by the constancy of boiling point of the esters and the high freezing point in Table 6. *Pangium edule* gives no hydnocarpic acid, as is shown by the lack of optical rotation. The remaining oils all yield hydnocarpic acid. Taking into consideration the weights and freezing points of both *a* and *b* fractions it is evident that *Hydnocarpus anthelminthica* and *H. subfalcata* show a better separation of hydnocarpic acid than the other extracted oils. Not much difference can be noted between *Hydnocarpus wightiana* and *Taraktogenos kurzii*, but *Hydnocarpus hutchinsonii* appears somewhat inferior as a source of hydnocarpic acid. The pressed oils on the whole give indications of better yields than the extracted oils.

Chaulmoogric acid occurs in *Hydnocarpus alcalae* in very large proportion, as has been mentioned. The other oils show much less chaulmoogric without much variation among themselves.

Iodine number.—The Hanus method, one hour absorption, was used.

In the hydnocarpic acid fractions, Tables 4 and 5, both *a* and *b*, the iodine number is in general lower than the theoretical for hydnocarpic acid (100.7). There is considerable variation in different samples of the same oil, *Hydnocarpus anthelminthica* being the only oil definitely lower than the rest.

The chaulmoogric fractions, Tables 8 and 9, show a definite tendency toward a higher iodine number in the *b* fraction. This is quite variable in different specimens of the same oil, sometimes showing considerable amounts of acid more highly unsaturated than chaulmoogric.

In the case of *Pangium edule* it is evident that the solid acids are chiefly palmitic and stearic, as they have low iodine numbers.

Specific rotatory power.—The hydnocarpic fractions, Tables 4 and 5, show noticeable uniformity in rotatory power. The *b* fractions give somewhat lower figures than the *a* fractions, showing the presence of an inactive acid. This is especially true of *Hydnocarpus anthelminthica*, which evidently contains an appreciable amount of palmitic or a similar acid.

The chaulmoogric fractions, Tables 8 and 9, show higher rotation than the hydnocarpic, although the reverse is true of the

pure acids. (Power gives 58.6° for chaulmoogric acid and 68.1° for hydnocarpic.) *Hydnocarpus alcalae* and *H. subfalcata*, however, show notable amounts of stearic or a similar acid (by their low rotation), and all of the oils have some inactive acid which remains in the *b* fraction.

The absence of chaulmoogric and hydnocarpic acid in *Pangium edule* would seem to be definitely shown by this determination. It is possible, however, that these acids are present together with an enzyme which causes their destruction. Sample *A* of *Pangium edule* was insufficient for the ester distillation test, so sample *B* was prepared. After the absence of rotation in the esters of this sample was discovered it was found that the oil itself had no rotation. The second-grade oil of sample *A* (Table 3) has a very low rotation. Unfortunately we have no more seeds available for further work on this at present, but the evidence so far points to the absence of chaulmoogric and hydnocarpic acids in *Pangium edule*.

Saponification number.—It was hoped that this value would enable us to make the determination of the relative amounts of 16-carbon-atom and 18-carbon-atom acids in each oil. In general, the fractions 2 *b* and 5 *b* show higher saponification numbers (lower molecular weights) than the corresponding *a* fractions, as was expected, while fractions 1 *b* and 6 *b* are about the same as 1 *a* and 6 *a*, since fractions 1 and 6 are each fairly homogeneous, in respect of molecular weight, being end fractions in the distillation. There is evidently, however, some cause of variation in the saponification numbers, the nature of which we cannot definitely state, and which makes them unreliable as indications of the relative amounts of 16-carbon-atom and 18-carbon-atom acids in a fraction.

CONCLUSION

The foregoing data show a close similarity between the oil of *Taraktogenos kurzii* and all the *Hydnocarpus* oils that we were able to obtain. The only one of the latter that is distinctly different is *Hydnocarpus alcalae*, which contains a very large amount of chaulmoogric acid, and little or no hydnocarpic acid.

The other *Hydnocarpus* oils, like chaulmoogra oil, may each be separated into fractions (by the distillation of the ethyl esters) containing 16-carbon-atom acids and fractions containing 18-carbon-atom acids. The 16-carbon-atom fractions of each contain hydnocarpic acid and an unknown acid or acids which can be separated only very incompletely from the hydno-

TABLE 4.—*Characteristics of fraction 1.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus alcalae:													
A, first grade	20	215–220		12.9	6.2	42	29	80	82	46	40		
B, first grade	16	–214	34	10.0	15.5	61	37	80	86	51	48	209	216
Hydnocarpus anthelminthica, first grade	26		42	11.5	27	50	39	83	64	46	35	235	225
Hydnocarpus hutchinsonii, first grade	23	220–223	42	19.5	15.5	39	35	78	81	47	49	215	203
Hydnocarpus subfalcata, A, first grade	20	205–218	42	6.0	28	47	41	83	85	46	49	207	214
Hydnocarpus wightiana:													
A, first grade	20	210–218	49	26.8	18.5	41	38	86	86	49	46	192.5	223
C	20	211–214	40	29	12.5	48	38	99	105	60	53	214	206
Pangium edule, B, first grade	20	–218	45	6.2	27.5	51	7	26	85	0	0	219	222
Taraktogenos kurzii:													
A, first grade	20	205–217	40	2.0	28.0	45	33	90	86	51	42	213	218
D	20	215–218	35	12.5	20.6	48	40	91	90	55	47		
F	20	205–214	52	11.8	19.8	41	25	91	99	54	41	214	209
G	20	209–218	45	11.5	17.0	42	34	93	94	52	45	215	216

TABLE 5.—*Characteristics of fraction 2.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus alcalae:													
A, first grade	20	220–225		11.9	17.3	59	34	82	87	55	46		
B, first grade	16	214–214	35	14.5	14.0	61	37	78	79	52	48	208	213
Hydnocarpus anthelminthica, first grade	26		44	4	30	49	41	75	78	53	39	228	223
Hydnocarpus hutchinsonii, first grade	22	223–224	42	15.0	21.0	37	35	75	87	52	52	195	204
Hydnocarpus subfalcata, A, first grade	20	218–221	43	15.7	20	44	42	71	87	50	44	217	216
Hydnocarpus wightiana:													
A, first grade	20	218–219	46	35	7.0	38	33	86	96	48	42	178	210
C	20	214–214	42	27.0	10.0	41	40	94	103	57	58	205	209
Pangium edule, B, first grade	20	218–221	44	3.2	30.0	50	15	22	80	0	0	206	216
Taraktogenos kurzii:													
A, first grade	20	217–220	43	13.5	22.5	41	32	91	87	51	42	213	216
D	20	218–218	37	12.0	23.5	49	41	92	88	58	49		
F	20	214–217	51	25.6	25.6	40	25	90	100	54	50	211	208
G	20	218–218	44	17.0	14.0	44	26	92	97	56	45	220	206

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TABLE 6.—*Characteristics of fraction 3.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus alcalae, A, first grade	20	225–230	51	19.8	13.5	64	34	91	102	56	49		
Hydnocarpus wightiana, C	20	214–216	40	29.1	21.0	37	36	90	106	53	54	191	209
Taraktogenos kurzii:													
D	20	218–219	42	27.0	12.1	46	39	91	93	55	46		
F	20	217–220	47	7.0	17.7	51	26	89	101	50	50	186	198
G	20	218–219	42	9.5	16.5	43	32	95	107	59	50	211	207

TABLE 7.—*Characteristics of fraction 4.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus wightiana, C	20	216–219	40	22.0	17.5	43	40	101	109	59	54	211	209
Taraktogenos kurzii:													
D	20	219–224	45	6.0	34.0	40	38	94	96	52	52		
F	20	220–224	47	19.5	23.3	53	27	95	121	51	54		199
G	20	219–226	47	7.5	18.8	49	31	103	105	52	47	204	202

TABLE 8.—*Characteristics of fraction 5.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Hydnocarpus alcalae:	*mm.*	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
A, first grade	20	230–232		33.4	13.2	64	38	92	144	58	49		
B, first grade	16	216–219	38	25.5	6.0	67	18	91	110	60	46	201	201
Hydnocarpus anthelminthica, first grade	26		50	23.5	20	60	29	79	83	46		208	221
Hydnocarpus hutchinsonii, first grade	19	227–227	38	18.0	17.5	63	35	81	99	58	48	195	206
Hydnocarpus subfalcata, A, first grade	20	223–229	40	11.0	27	59	34	90	85	48	38	209	191
Hydnocarpus wightiana:													
A, first grade	20	223–231	43	13	26	65	29	96	100	60	49	197	217
C	20	219–223	40	18.5	17.5	55	38	104	110	58	57	204	210
Pangium edule, B, first grade	20	223–225	43	1.8	31.5	57	7	37	101	0	0	179	211
Taraktogenos kurzii:													
A, first grade	20	227–231	40	7.0	26.3	57	31	92	85	49	42	195	204
D (214.5 g. used)	20	224–230	17	5.0	10.0	61	38	89	101	56	49		
F	20	224–226	44	25.3	16.0	59	28	91	138	52	54	173	199
G	20	226–232	40	12.0	4.6	63	26	113	108	54	52	204	200

TABLE 9.—*Characteristics of fraction 6.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]_D^{30}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus alcalae:													
A, first grade	20	232–		24.4	3.4	55	44		137				
B, first grade	16	219–	29	18.0	8.0	65	29	86	86	59	41	199	216
Hydnocarpus anthelminthica, first grade	26		47	4.9	32.4	52	37	79	90	41	43	223	225
Hydnocarpus hutchinsonii, first grade	18	227–233	35	22.0	9.5	66	35	81	101	63	48	194	201
Hydnocarpus subfalcata, A, first grade	20	229–238	59	40.2	16.0	62	37	90	90	44	34	204	210
Hydnocarpus wightiana:													
A, first grade	20	231–234	30	12.5	21.5	64	36	95	92	52	35	203	205
C	20	222–229	50	40	10	54	29	99	124	53	51	184	186
Pangium edule, B, first grade	20	225–237	40	2.0	28.5	52	5	43	90	0	0	177	197
Taraktogenos kurzii:													
A, first grade	20	231–242	52	14.5	28.9	59	28	91	83	47	39	208	206
D	20	230–232	20	11.2	6.0	61	38	99	102	55	47		
F	20	226–226	8	5.0	1.6	61		101		54		203	
G	20	232–	21	6.3	7.6	58	16	92	98	48	43	203	193

carpic by one crystallization from 80 per cent alcohol. This unknown acid portion is optically inactive or at least less active than hydnocarpic. The 18-carbon-atom fractions contain chaulmoogric acid, which can be separated out more readily than can the hydnocarpic above mentioned. A more highly unsaturated portion is left, in the case of many samples, when the chaulmoogric acid is crystallized out.

No reason appears for considering chaulmoogric oil to be superior to the *Hydnocarpus* oils in general for therapeutic purposes. Clinical data on this point, however, are lacking, and must be obtained before any positive statements can be made. Even more important is the clinical study of the various components of the hydnocarpus oils, as it is probable that when the effects of each is well known better therapeutic results can be obtained than are possible at present.

Brill's results on *Gynocardia odorata* were evidently due to a confusion of this seed with that of *Taraktogenos kurzii*, which confusion still exists in Assam in spite of the ease with which the seeds can be distinguished.

Brill's conclusion that chaulmoogric or hydnocarpic acid is contained in *Pangium edule* is rendered doubtful by our experiments. Some variable optically active constituent is contained in the fatty acid fraction, however, possibly the above-mentioned acids together with a destructive enzyme.

SUMMARY

1. The analytical data existing in the literature on the chaulmoogra group of oils have been summarized and found to be qualitative and incomplete.

2. Authenticated seeds of ten species related to chaulmoogra and fifteen samples of commercial oils were studied for the purposes of (*a*) establishing criteria for the recognition of each oil and for the detection of adulteration, (*b*) sufficiently separating each oil into its components to enable its evaluation as a potential source of hydnocarpic acid, chaulmoogric acid, or other therapeutically valuable constituents, and (*c*) determining economically important data.

3. The seeds were graded and extracted by solvents. The oils thus obtained as well as the commercial oils were examined for specific gravity, refractive index, freezing point, optical rotation, iodine absorption, saponification number, and acidity, and their fatty acids for freezing point and specific rotatory power.

4. Thirteen of the above-mentioned oils were partially resolved by the fractional distillation of the ethyl esters of their fatty acids followed by a crystallization of the recovered fatty acids from each of four fractions. The eight resulting fatty acid fractions from each oil were examined for freezing point, iodine absorption, specific rotatory power, and saponification number.

5. Previous results placing *Gynocardia odorata* outside of the chaulmoogra group have been confirmed. *Pangium edule* appears to contain no chaulmoogric or hydnocarpic acid.

6. *Hydnocarpus alcalae* was found, in confirmation of Brill's results, to contain a large amount of chaulmoogric and little or no hydnocarpic acid. The remaining *Hydnocarpus* oils studied were found very similar to chaulmoogra in chemical composition.

ILLUSTRATION

[Photographs by the Bureau of Science.]

PLATE 1.

FIG. 1. Seeds of *Hydnocarpus subfalcata* Merrill, from Zambales, P. I.

2. Chaulmoogra-group seeds, Philippine and foreign.

a. *Taraktogenos kurzii* King, true chaulmoogra, from Assam.

b, *Hydnocarpus alcalae* C. de Candolle, dudu-dudu, from Albay, P. I.

c, *Hydnocarpus hutchinsonii* Merrill, mansaloka, from Zamboanga, P. I.

d, *Hydnocarpus anthelminthica* Pierre, lukrabao, from Cambodia.

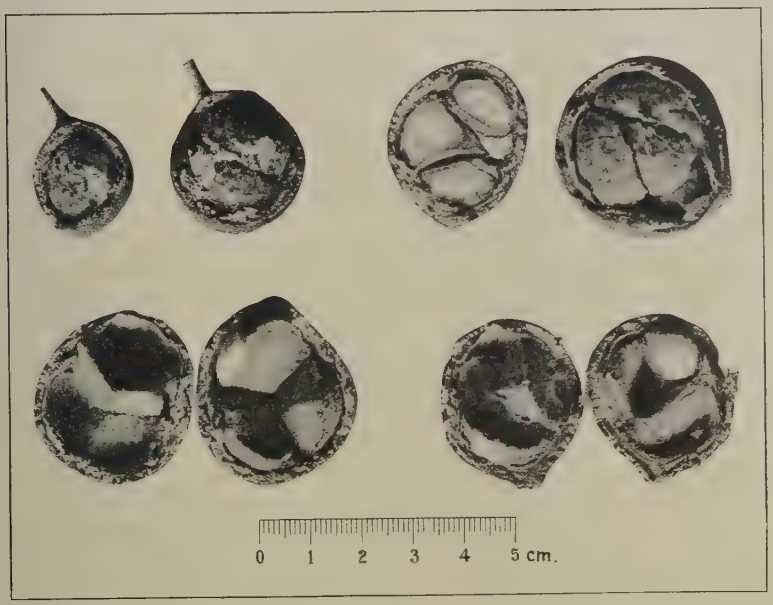

Fig. 1. Seeds of Hydnocarpus subfalcata, from Zambales.

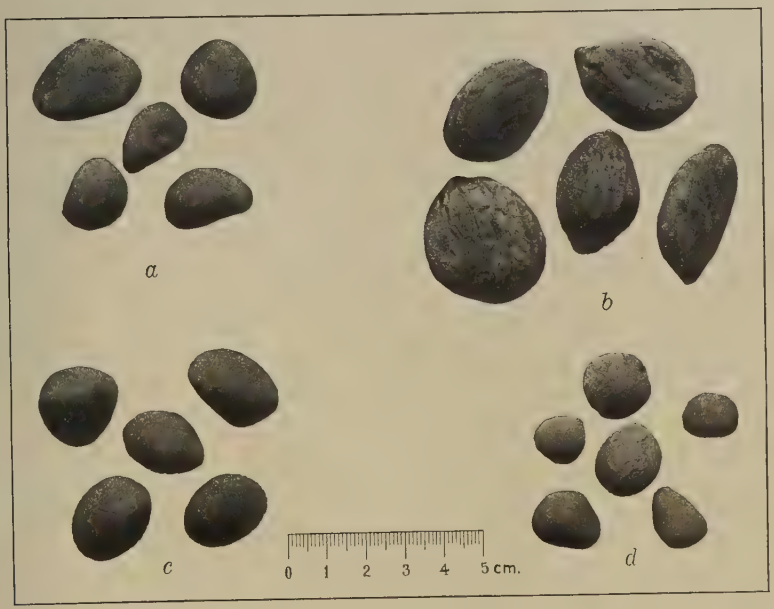

Fig. 2. Chaulmoogra-group seeds, Philippine and foreign.

PLATE 1.

A NEW PHILIPPINE BIKKIA

By Th. Valeton

Of Leiden, Holland

BIKKIA PHILIPPINENSIS sp. nov.

Frutex habitu generis. Ramulus 6 mm crassus, medio defoliatus et fructifer, internodiis brevibus, foliis cum floribus axillaribus versus apicem confertis. Stipulae in annulum connatae, apice brevi-apiculatae et subcarinatae. Folia elliptico-lanceolata (major 11 × 3.5 cm), apice obtusa acute submucronata, basi attenuata in petiolum decurrentia, mediocrem, in sicco crasse rigide coriacea, ochracea, costa lata nervis subimmersis. Flores tetrameri ceterum iis *B. grandiflorae* similes, corollae tubo proratione magis elongato. Calycis lobi late lanceolati ancipites, acuti, circiter 10 mm longi, post anthesin elongati, ovarium longitudine aequantes. Corollae tubus (in alabastro maturo) 50 mm longus, sensim in limbum angustum dilatatus. Lobi trigoni acuti, lateraliter leviter emarginati. Ovarium argute costulatum, biloculare. Placenta in quoque loculo lamelliformis apice bifida ramis appressis vel demum recurvis et incrassatis extus ovuligeris. Capsulae parvae, 28 mm longae, bivalvae, valvis fere ad medium usque fissis, demum epicarpio denudatis et contortis, apice 20 mm latis, obtrigonis; fibrae epicarpii 8, filiformes.

Cebu, Mualbual, *Elmer 12052,* October, 1909. (The same species is also represented by *Merrill 5297* from Sibutu, Sulu Archipelago, and *Bur. Sci. 34428, 34583 Ramos & Pascasio,* Surigao Province, Mindanao. All specimens were originally determined as *Bikkia grandiflora* Reinw.—E. D. M.)

In habit this species is strikingly similar to *Bikkia grandiflora* Reinw., but the 4-fid fruit, the bifid valves of which are wholly detached from the placenta, and the structure of the ovary indicate that its proper place is in the subgenus *Eubikkia;* the type of this subgenus is *Bikkia tetrandra* A. Gray, based on *Portlandia tetrandra* Forst. from Savage Island. *Bikkia grandiflora* Reinw., from the structure of its ovary and its fruit, belongs in the subgenus *Bikkiopsis,* which is typified by *B.*

pancheri Deplanche of New Caledonia. To this subgenus *B. commersoniana* K. Schum. belongs, as demonstrated by Schumann, and to it must also be referred the type of the genus, *Bikkia grandiflora* Reinw., which up to the present time I, as well as other authors, had supposed to be identical with *Portlandia tetrandra.* To the section *Eubikkia,* in addition to *B. philippinensis* and *B. tetrandra, B. mariannensis* is to be referred, as well as an unpublished species from the Palau Islands. To *Bikkiopsis* are to be referred all of the species from the Moluccas and New Guinea and some of those from New Caledonia.

TREATMENT OF LEPROSY WITH ANTIMONY [1]

By José Rodriguez and Froilan Eubanas

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INTRODUCTION

The best of the newer methods of treating leprosy fall so far short of what is hoped will be ultimately attained that any therapeutic measure that may be of value, whether as an auxiliary to the chaulmoogra preparations or in their stead, should be tested thoroughly. It was for this reason, and without prejudice in the matter, that when encouraging reports on the use of antimony preparations were brought to the attention of the Culion authorities by Doctor Cawston, of Natal, we were requested to try them out on cases under our care.

Cawston [2] reported remarkable results obtained in Natal with tartar emetic and a proprietary colloidal preparation of antimony known as oscol stibium, though he stated that the tartar emetic can be given with benefit by mouth in the form of vinum antimonii. He claimed that paralyses were relieved, ulcers dried up, and the general condition of the patient improved within a remarkably short time. He also noted relief in the various eye complications so commonly seen in this disease. Wildish [3] obtained similar results in the Amatikulu Leper Institution in Zululand, and concluded that antimony is of very decided value in the treatment of leprosy, more particularly in cases exhibiting severe manifestations of the disease.

TARTAR EMETIC ADMINISTERED INTRAVENOUSLY

A simple, 1 per cent solution of tartar emetic in distilled water was given intravenously to a group of inmates of the General Hospital of the Culion Leper Colony for a period of six months. The solution was always freshly prepared as it tends to precipitate after a few days. Sterilization was effected by flowing

[1] Published with the approval of the Philippine Leprosy Research Board and the consent of the Director of Health.

[2] Cawston, F. G., Brit. Med. Journ. No. 3107 1 (1920) 76, 77; No. 3127 2 (1920) 855, 856; No. 3142 1 (1921) 419.

[3] Wildish, G. H., Brit. Med. Journ. No. 3185 1 (1922) 55.

steam, Castellani[4] having advised against heating under pressure.

Thirty-one patients were selected from among the best-nourished inmates of the wards. Under the system followed in this colony chiefly advanced cases that require hospital care on account of deformities, or treatment of complications and sequelæ, are assigned to the General Hospital. Among those chosen for the experiment eight showed signs of pulmonary tuberculosis; only one of these was given the treatment for the full period of the experiment.

Thirty of the cases were lepers; one, found to have ulcerative tertiary yaws, received injections for two months before she was sent home. Though eliminated from consideration as a leper, this case served to some effect as a control.

In most of the cases the disease was advanced. Efforts were made to represent all types and degrees of ulcerations, contractures, deformities, and eye complications. None of the cases could be classified as pure cutaneous. Seven were neural, and twenty-three mixed. The ages are given in Table 1; the majority were above 30 years of age, and 36 per cent were in the fourth decade. The duration of the disease is shown in Table 2. The greatest duration was twenty-two years, the shortest two, and the average eleven.

TABLE 1.—*Age distribution of cases treated.*

Age. Years.	Cases.
To 15	1
16 to 20	5
21 to 30	6
31 to 40	11
41 to 50	3
51 to 60	4
Total	30

TABLE 2.—*Duration of leprosy in cases treated.*

Duration. Years.	Cases.
4 or less	2
4 to 8	5
8 to 12	14
12 to 16	6
16 to 20	2
20 to 22	1
Total	30

[4] Castellani, A., and Chalmers, A. J., Manual of Tropical Medicine 3d ed. (1920) 1297.

In the preliminary examination, cutaneous sensibility to light touch, deep touch, heat and cold, and pain was determined and charted. Nodules, contractures, eye lesions, and other features of interest were described and in many cases photographed. The ulcers were counted and the more prominent ones measured. Bacteriological examinations were made from the cutaneous lesions or, in the absence of such, from the nasal septum. The acuteness of vision in those presenting involvement of the eyes was also tested. The urine of each was examined at least four times during the period; before starting treatment, after two months, after four months, and at the completion of the experiment.

TREATMENT

During this period no other treatment was given that could obscure the results. Ulcers were washed with weak potassium permanganate solutions and dressed daily, as were those of others in the wards. The patients were maintained under exactly the same general conditions as were the others, who therefore served in a way as controls.

The doses of the drug tolerated by our cases were much lower than those used in other tropical diseases such as kala-azar, sleeping sickness, etc., in which as much as 10 milliliters of the 1 per cent solution is injected daily for ten or more days. To avoid irritation of the kidneys, since chronic nephritis is common among Culion lepers, the first dose was fixed at 0.5 milliliter, or 0.005 gram of tartar emetic. This was increased by 0.5 milliliter at each weekly injection, up to 2.5 milliliters, or 0.025 gram. With this dose most of the patients became weak, complained of various ill effects, and urine examination revealed evidence of kidney injury in the majority of cases. The amount of the dose was then reduced to 1.5 milliliters, or 0.015 gram, with which dose most of the objectionable side effects were no longer noticed. In three cases the urine cleared up under this dose.

As the larger dose was clearly harmful, an attempt was made to give the drug more frequently in smaller amounts. This was tried on two patients who were already showing signs of improvement; the results proved disastrous as shown by the following notes:

Case 10.—N. T. Ulcers improving up to the ninth injection of 2.5 milliliters. Patient began to cough, and ulcers to return, so dose was reduced to 2 milliliters and, finally, to 1.5 milliliters, when improvement began again. After four injections at this dose the interval was reduced

to three days. After six such injections of 1.5 milliliters he began to have persistent abdominal pain, diarrhœa, prostration, and finally passed blood per rectum. Injections were suspended and the diarrhœa disappeared without any other treatment.

Case 11.—P. C. After the first two injections the ulcers began to heal, but on increasing the dose to 2.5 milliliters they began to break out again, and albumin appeared in the urine. After a brief rest the injections of 1.5 milliliters were resumed and the ulcers again improved. The injections were then given every three days. After six injections the patient became very weak, the old ulcers broke out afresh all over the body, and a large one appeared in the larynx, which made swallowing very difficult. The drug was discontinued and the ulcers improved, but that of the larynx persisted and the patient died in less than a month. Autopsy was not performed.

As a result of these experiences the dose usually given thereafter was 1.5 milliliters per week, though in some cases it was occasionally increased to 2 milliliters.

RESULTS OF TREATMENT

Of the thirty cases of leprosy put under treatment, five died before the end of the experiment, that is, within six months. Another died two weeks after its conclusion; in the discussion below this case is not included among those surviving at the end of the experiment. The mortality during the experimental period was, therefore, 16.1 per cent; the sixth death brings it up to 19.3 per cent. The results obtained in the survivors are shown in Table 3.

TABLE 3.—*Results of treatment in the twenty-four surviving cases.*

Result.	General condition.	Leprotic lesions.	Ulcers.
Much improved	0	0	1
Improved	2	0	5
Not improved	15	23	14
Worse	7	1	4
Total	24	24	24

General condition.—The results, so far as the general condition is concerned, are quite unsatisfactory. Not only did none of the survivors show much improvement, but a large proportion of them became worse during the experiment.

Leprotic lesions.—No improvement whatever could be seen in the leprotic lesions. No case in the series became bacteriologically negative.

In only one case (Case 21) did the injection induce the phenomenon known as lepra fever. On two occasions in this case severe exacerbations of the disease occurred. Numerous small nodules appeared all over the body and these ulcerated within a few days, so that it seemed as if practically the entire integument was converted into an oozing sore. This patient died suddenly two weeks after the end of the experimental period.

Ulcers.—There was apparent improvement of the ulcers in six cases, 25 per cent of the survivors; in fourteen, 58 per cent, they showed no change; in four, 1 per cent, they became distinctly worse.

It seems that the results with ulcers were influenced by two factors besides the drug itself, namely, the duration and the type of the ulceration. Table 4 gives the figures on the relation of duration and improvement.

TABLE 4.—*Relation of duration of ulcers and their improvement.*

Duration of ulcers.	Cases.	Improved.		Stationary.		Worse.	
Years		*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
1 to 2	14	7	50	5	36	2	14
3 to 4	7	1	14	4	57	2	29
5 to 6	7	0	0	5	71	2	29
Over 6	2	0	0	2	100	0	0
	30	8	27	16	53	6	20

In half of the cases that had suffered from ulcerations for from one to two years improvement was noted, whereas none was noted in those of over four years duration.

As to the type of ulcer, the best results were noticed in the superficial ulcerations affecting the soles of the feet. In all four cases presenting this type, they were improved. Some improvement was also noticed among those having infected generalized lepromatous ulcers as shown in Table 5.

TABLE 5.—*Type of ulcer and results of treatment.*

Type of ulcer.	Improved.	Stationary.	Worse.	Total.
Infected lepromatous	5	9	5	19
Superficial plantar	4	0	0	4
Of foot, with sinus	0	4	0	4
Total	9	13	5	27

Two cases of clavus and of leprotic adenitis showed no improvement.

There is no indication of greater improvement with larger dosage. On the contrary, none of the ten patients receiving the highest average doses per injection were improved in any respect. Five of the six deaths are included among these ten; only three finished the experiment; the rest had to be dropped.

UNTOWARD EFFECTS OF TREATMENT

Twenty-three of the leprosy patients showed ill effects of some kind or other and only seven remained free. Table 6 gives all such symptoms observed.

TABLE 6.—*Untoward effects of treatment in leprosy cases.*

Symptom.	Cases.	Occurrences.
Systemic:		
General weakness after injection	9	19
Fever after injection	22	34
Chill	7	14
Exacerbation of leprotic lesions	1	2
Nervous system:		
Headache	11	25
Sensation of heat without fever	2	2
Neuralgic pain	3	6
Insomnia	1	4
Digestive system:		
Abdominal pain	4	4
Diarrhœa	3	5
Transient epigastric pain	2	2
Nausea	2	2
Respiratory system:		
Exacerbation of cough	3	10
Chest pain	3	12
Hæmoptysis	1	1

The commonest reaction was a brief slight fever that appeared a few hours after injection. This occurred thirty-four times. The fever seldom rose higher than 38° C. and was discovered only by taking the temperature as a matter of routine. The next commonest complaint was headache, which was rather severe at times. This was observed twenty-five times in eleven of our patients. Nine complained of general weakness after injection; this occurred nineteen times, usually accompanied by slight dizziness. Chill a few minutes after injection was occasionally observed. Nausea was noticed only twice. The nonleper had slight fever following an injection once during the period.

The most serious reaction was diarrhœa with abdominal pain. These symptoms were complained of by three patients, two of whom died. Treatment was stopped in the third case and apparently a fatal termination was averted; the diarrhœa disappeared without further treatment. When, in the course of a series of injections with tartar emetic, these symptoms appear, the drug should be discontinued at once. On the other hand, transient abdominal pain need not be taken seriously.

NEPHRITIS

The greatest drawback to the use of this drug in our cases was its effect on the kidneys. Examination of the urine as a routine measure at stated intervals brought to light evidence of kidney damage in a large proportion of the cases treated, in spite of the small doses used.

Twelve of those with negative urine at the start became positive for albumin within two months, though in most only traces were found. Casts appeared in four of these cases, and in one of them blood casts were observed, indicating the degree of irritation to which the kidneys had been subjected. Six had albumin at the outset; two of these died, one was dropped from treatment, in one the kidney condition cleared up, and in the other two it was aggravated. The nonleper showed no evidence of kidney injury.

TUBERCULOSIS

Eight patients showed evidence of pulmonary tuberculosis at the outset. One had hæmoptysis after receiving 8 milliliters in six injections. This case, together with three others who showed marked injurious effects, had been dropped within five weeks after starting; one of them died after having developed what was evidently a psoas abscess.

Only one of the eight tuberculous patients finished the six months course. The tuberculous process was accelerated in several cases, and in one markedly so, as confirmed by autopsy. Another died from persistent diarrhœa, apparently caused by the drug, not from the effects of the lung lesion.

SUBSEQUENT OBSERVATIONS

Six months after the conclusion of the experiment the surviving patients were reëxamined. Three had continued to improve, so far as the ulcerations were concerned; all of these had been taking chaulmogra oil by mouth since the end of the experiment. Three had become worse, and the rest remained stationary.

NOTES ON FATAL CASES

The following are notes on five of the six cases who died during the observation period. One, Case 10, N. T., has already been described.

Case 14, clinical features.—F. Y., male, 46 years old. Treatment was begun June 9, 1922. Patient fairly strong, though somewhat emaciated. Apices dull, bronchial breathing right, but no râles.

In four weeks six doses totaling 8 milliliters had been given. Complained of weakness, and hæmoptysis occurred on the day after the last injection. Dropped from treatment and gradually improved. Hæmoptysis did not recur. Two months later tenderness noticed in right iliac region over a mass which gradually became more superficial. Death a month later, when the mass, apparently a psoas abscess, seemed about to rupture. Unfortunately, autopsy was not performed.

Case 28, clinical features.—M. N., female, 34 years old. At beginning well nourished, apparently strong, though with fairly advanced pulmonary tuberculosis. Upper parts both lungs dull, with bronchial breathing and a few subcrepitant râles. After the fifth injection severe abdominal pain and diarrhœa developed, appetite completely lost, with marked prostration. A few days before death cough increased and fever became constant. The lung lesions had progressed very rapidly, with signs of cavity formation in both lungs.

Although severe abdominal pain was frequently complained of, there was no localized tenderness. Spleen and liver not felt. Urine became positive for albumin, but there was no œdema. Died two months and eight days after beginning treatment, having received but five injections in the first month.

Autopsy 78 (Dr. E. V. Pineda).—Upper lobe left lung almost completely destroyed by tuberculous cavitations. Right upper lobe contained cavities and also conglomerated tubercles. Numerous tubercles in lower lobes, both lungs. Indications are of a rapidly advancing process.

Spleen flabby and slightly enlarged, cut surface deep chocolate, marked increase in the stroma. Liver enlarged, soft, flabby, and friable, cut surface opaque, lobules rather indistinct. Nothing of interest in the alimentary tract. Genital organs congested and hypoplastic, otherwise negative. Kidneys slightly smaller and firmer than normal; on section cortex thin and slightly translucent, minute red vessels shining through. Capsule stripped with difficulty, tearing kidney tissue at points.

Diagnosis: Pulmonary tuberculosis, ulcerative and chronic miliary; pleuritis, chronic; nephritis, chronic; leprosy.

Case 18, clinical features.—S. V., female, 40 years old. Had ulcerations of feet and legs and dry gangrene of tips of the toes. Diarrhœa developed after beginning treatment, persistent and weakening. Also severe neuralgic pains along legs. Lungs markedly dull at apices, bronchial breathing, a few sibilant râles.

In twelve injections was given only 21.5 milliliters over a period of thirteen weeks. Urine showed traces of albumin before; after second month, cast found. Death occurred September 20, 1922, fifteen weeks after the beginning of experiment.

Autopsy 99 (*Dr. E. V. Pineda*).—Lungs filled with miliary tubercles. At apices conglomerated and surrounded by fibrosis. Peribronchial lymph nodes enlarged, black, rather soft; on cut surface a few grayish white tubercles. Heart slightly heavier than normal, pale, with a few yellowish glistening streaks in the muscle tissue. Spleen slightly larger than normal and flabby, grayish red, stroma markedly increased. Liver normal in size, slightly congested, cut surface rather opaque, lobules fairly distinct, with central congestion, tissue friable.

Kidneys normal in size, weight, and color of cut surface; cortex and medulla both thin. First portion of cæcum showed slight hyperplasia of lymphoid element, with a few petechial hemorrhages. Brain showed slight œdema of pia. Two ulcers found on epiglottis.

Diagnosis.—Pulmonary tuberculosis, chronic, miliary; nephritis, chronic (slight); multiple ulcers, skin; ulcers, epiglottis; leprosy.

Case 20, clinical features.—S. R., female, 43 years old. At beginning, apices dull and a few moist râles, right infraclavicular. A low systolic murmur was heard best at the base. Second pulmonic distinctly accentuated, but the murmur not transmitted to axilla and cardiac area not enlarged. Tender mass in right axilla. Patient anemic. Only traces of albumin in the urine; no œdema seen.

Patient under actual treatment for twenty-two weeks, receiving twenty injections totaling 32 milliliters. No untoward symptoms noticed, but occasional fever, headache, sometimes chest pain. After second and fourth months abundant albumin and casts found.

Died suddenly November 11, three days after the last injection of 1.5 milliliters. Complained of severe abdominal pain at midnight, vomited several times, dying within three hours.

During treatment the multiple superficial ulcerations much improved. An acute adenitis, right axillary, developed and burst; the fistula healed very slowly.

Autopsy 130 (*Dr. F. Solis*).—Axillary sinuses only important finding noted. Communicated with enlarged lymph nodes containing abundant caseous material liquefied centrally. In lungs, peribronchial nodes, heart, liver, kidneys, alimentary tract, and brain nothing pathological recognized. Spleen was smaller and firmer than normal, stroma reddish brown, distinctly increased.

Diagnosis.—Cause of death not determined. Adenitis, tuberculous; leprosy.

Case 21, clinical features.—P. S., female, 36 years old. Fairly well nourished. A few sibilant râles left interscapular, with impaired resonance. Slight œdema of legs; only traces of albumin in urine.

Injected twenty times in twenty-six weeks, totaling 34 milliliters. After second month urine loaded with casts, and albumin heavy. Œdema not more marked. Twice severe lepra reaction developed, principally fever and generalized papules that soon ulcerated but healed completely in remarkably short time, two weeks.

Suddenly, two weeks after last injection, complained of severe abdominal pain with vomiting and collapse, rapid, soft pulse, subnormal temperature, extremities cold, sweat-covered. Restless, moaned continuously, but answered questions fairly well. Face livid, respiration shallow and accelerated. Lungs dull at apices, with bronchial breathing right. No

râles. A systolic murmur at apex, not transmitted to axilla. Cardiac area not enlarged. Heart beats faint, rapid but regular. No localized resistance or tenderness in abdomen. Spleen and liver not felt. Reflexes normal. No œdema. Died after six hours, in spite of treatment.

Autopsy (*Dr. E. V. Pineda*).—Heart slightly larger than normal, musculature grayish red, but endocardium opaque and grayish white. No definite tuberculosis, but slight fibrosis, right apex. Spleen normal in size, wrinkled, stroma markedly increased. Liver congested, deep red, cut surface darker than normal, mottled. Alimentary tract normal throughout. Kidneys normal in size, and slightly softer than normal. Cortex thin, pale, with a few cortical cysts. Capsule stripped off with slight difficulty, tearing surface at points.

Diagnosis.—Nephritis, chronic, slight; leprosy. Immediate cause of death not determined.

Histologically (Doctor Pineda) kidneys showed chronic parenchymatous nephritis; heart cloudy swelling; spleen chronic interstitial splenitis with miliary lepromata; liver chronic passive congestion, slight proliferation of bile ducts, and miliary lepromata. Sections of lung examined normal.

TARTAR EMETIC IN LEPRA FEVER

Tartar emetic by mouth has been tried out by certain members of the staff at Clinic 2, in the treatment of the so-called lepra fever. It was given in a mixture of sodium salicylate and sodium bicarbonate, in doses that represented 8 centigrams of the tartar emetic per day.

It has been possible to gather data on twenty-nine cases of lepra fever treated solely with this formula, receiving from 0.24 to 1.96 grams of tartar emetic during the treatment. The average duration of stay in the hospital for these cases was twenty-seven days, four days more than the average hospitalization for 1922 in this clinic, which was reported as twenty-three days.

Two cases in this group died; these had chronic nephritis on admission to the hospital. One of them developed uremic symptoms after ten days of treatment, during which time he had received about 0.9 gram of the drug. The other was given 1.80 grams in twenty-five days before he died, the prominent symptoms toward the end being progressive weakness, loss of appetite, drying up of ulcers, and vomiting.

In four other cases œdema of the legs and albumin in the urine were noticed during the treatment. One of these received only 0.24 gram, the second 0.32 gram, the third 0.56 gram, while the amount given the fourth could not be determined.

It is not possible, for lack of control observations, to say positively whether these patients improved more rapidly or less

rapidly under this treatment than they would have done without it. Comparison of the figures given with those of Clinic 1, where the medication was not given, is unsatisfactory. Here, fifty cases of lepra fever had an average hospitalization of twenty-one days, six days less than the Clinic 2 group, but six days more than the reported 1922 hospitalization average of fifteen days, which is more than the four-day extra period of Clinic 2.

The data from the two clinics are, unfortunately, not directly comparable, as there are important differences in the cases registered. Clinic 1, established a year earlier, has many of the more favorable cases, whereas Clinic 2 has a high proportion of advanced cases of long duration, less favorable for treatment. The only conclusion that can be drawn is that tartar emetic in these cases was without any striking benefit. As a matter of fact, this method of treatment was discontinued because there was not only no evidence of improvement as a result of it, but distinct evidence of injury to the kidneys.

TREATMENT WITH ANTIMONY WINE

While the experiment with tartar emetic administered intravenously was in progress, a cough mixture containing wine of antimony was given to twelve other General Hospital cases. Most of them had cough due to pulmonary tuberculosis; two had probable leprotic ulceration of the larynx, the lungs being negative. The doses were equivalent to from 2 to 3 milliliters of the wine daily, or 0.008 to 0.012 gram of tartar emetic. The treatment was continued for six months.

Of the cases put under treatment, two left the hospital after a short time, and one was dropped because of chronic nephritis. Of the remaining nine, two showed improvement of the cough, two remained practically stationary except for slight improvement of ulcers, two became distinctly worse, both as regards the cough and the ulcerations, and three died. None showed improvement of the leprotic lesions at the end of the six months.

Antimony wine was also given undiluted to another group of ten patients of similar type. The dose was 3 cubic centimeters a day at the start; this was gradually increased until some were taking as much as 9 cubic centimeters per day, equivalent to 0.036 gram of tartar emetic. At this dose it caused nausea and occasional diarrhœa. It was administered for periods of fifteen days with five rest days between, over the six months.

Four of the ten were dropped after a month because they flatly refused to continue taking the drug. They had suffered nausea and weakness, even with the initial dose. At the end of the period two showed some improvement in the ulcerations, but the remaining four were exactly the same as before treatment, so far as could be determined; the leprous lesions seemed in no way affected.

CASTELLANI MIXTURE

In connection with the trial of tartar emetic as a treatment in leprosy it seemed of interest to determine whether the formula proposed by Castellani for treating yaws would be of benefit in leprosy. It contains not only tartar emetic, the effect of which on leprosy it was desired to test particularly, but also a fairly large amount of potassium iodide. This has been used variously in leprosy, particularly after Danielson's advocacy of it and, while it has long since been discarded as a means of treatment, it is still cited as an agent for exciting a reaction that may be of service in diagnosis. It was possible that in the combination used this effect might prove beneficial.

CASES TREATED

Twelve General Hospital patients were put under this treatment, most of them bedridden cases. One of these, who had tuberculosis, had to be dropped after eleven doses because of exacerbation of the lung lesions. There were eight males and four females. Incidentally, this is the proportion existing in the general population of the Culion Leper Colony, according to the colony statistics. The age varied considerably; one was 20 years old, five were between 20 and 30, four were between 30 and 40, and two were between 40 and 50. The average was a little over 31 years, undoubtedly considerably higher than that of the total colony population.

Three cases were classified as pure cutaneous, one as neural, and the remaining eight as mixed, the commonest type among well-advanced cases. In only one case was the duration less than five years; in this it was three. In five it was six to eight years, in four it was ten to twelve, in one it was sixteen, and in one it was thirty-two years. The average, approximately eleven years, is high for the colony, but not particularly so for the inmates of the General Hospital. In two cases the disease was advanced, in the rest it was moderately advanced. Five had no ulcers, another five of the cases had only a few, from one to five in number, and in only two were they numerous.

FORMULA AND DOSAGE

The formula used in this experiment was the revised one of Castellani [5] except that the amounts of glycerine and water were increased from 8 and 22 milliliters to 40 and 60 milliliters, respectively:

R/	Tartar emetic	0.065 gm.
	Sodium salicylate	0.650 "
	Potassium iodide	4.000 "
	Sodium bicarbonate	1.000 "
	Glycerine	40.000 ml.
	Aqua q. s. ad	60.000 ml.

The above amount was given in two days, the patient taking 15 milliliters of the mixture, diluted with water, twice daily. Each dose thus contained 1.625 centigrams of tartar emetic and 1 gram of potassium iodide. In the treatment of frambœsia with this mixture Castellani gives the full formula three times a day, and in the Philippines Guerrero [6] and his coworkers, after beginning with one-third dose three times on the first day, and giving a full dose twice on the second day, was able to give a full dose three times on the third and subsequent days.

The treatment was given for eight consecutive days, making a total of 240 milliliters in this period. The sixteen doses so given were considered a series, and one series was given each month for three successive months.

The medicine was given after meals to avoid as far as possible gastric irritation. For the same reason the dose was not increased, although in using a colloidal preparation of antimony, "oscol stibium," Cawston advises pushing the dosage until toxic symptoms, as diarrhœa, are seen. The administration of the medicine is not without difficulty, as even among nonlepers this mixture often upsets the stomach as observed in cases of yaws so treated.

Among the most important immediate after effects have been those referable to the irritation of the gastrointestinal tract. Lepra fever, with constitutional disturbances, has been another difficulty. When this occurred the medicine had to be stopped temporarily until the fever subsided. The bad taste of the medicine is in itself a difficulty, as it is intolerable to some patients, who sometimes refused absolutely to take it.

[5] Castellani, A., and Chalmers, A. J., Manual of Tropical Medicine, New York, 3d ed. (1920) 1563.

[6] Guerrero, L. E., Domingo, E., and Arguelles, M., Philip. Journ. Sci. § B 13 (1918) 191.

TOTAL AMOUNTS ADMINISTERED

Of the remaining ten cases one patient took thirty doses, representing practically 49 centigrams of the tartar emetic, and two took forty and forty-four doses, or 65 and 72 centigrams, respectively. Seven took the full forty-eight doses or more, six being given fifty-one to fifty-three doses, or 52 to 86 centigrams of tartar emetic. The potassium iodide taken by this main group amounted to 48 and 53 grams. One patient refused to continue the treatment after taking six doses. In another case with pulmonary tuberculosis treatment was suspended after eleven doses, on account of poor condition of the patient.

RESULTS OF TREATMENT

Though the total time involved was but three months, which is too short to expect much real improvement in well-advanced cases of leprosy, nevertheless it was felt that, were the treatment of much value, there would be some improvement by the end of that time. This expectation was based in large part on the reports referred to.

The results obtained were not encouraging. Neither in the general condition nor in the disease itself was there any marked evidence of improvement. The results are tabulated in Table 7 and summarized in Table 8.

TABLE 7.—*Result of treatment with Castellani mixture.*

Case No.	Type.	General condition.	Leprosy lesions.	Ulcers.
1	Mixed	Stationary	Slight improvement	None.
2	Cutaneous	do	do	Slight improvement.
3	do	do	do	Do.
4	Mixed	do	Stationary	None.
5	do	Worse	do	Stationary.
6	Cutaneous	Stationary	do	Do.
7	Mixed	do	do	Do.
8	do	Worse	do	None.
9	do	Stationary	do	Slight improvement.
10	do	do	do	Stationary.
11	Neural	do	do	None.
12	Mixed	do	do	Do.

TABLE 8.—*Summary of data in Table 7.*

	General condition.	Leprosy lesions.	Ulcers.
Slight improvement	0	3	3
Stationary	10	9	4
Worse	2	0	0

As regards the general condition, no patient claimed to feel better than before treatment, and in none was any evidence of improvement apparent. On the contrary, two cases were evidently worse, due to repeated attacks of lepra fever. Loss of appetite, a frequent complaint, may have had something to do with this general result.

The leprotic lesions in the majority of cases showed no signs of improvement. In three, however, two nodular and one mixed, there was slight improvement. This consisted of only slight thinning of the nodules and of some of the infiltrations on the face and extremities.

More improvement was noticed in the ulcerations than in any other feature. In three, 42 per cent of those with ulcers, there was some improvement. The ulcers that improved were not the trophic plantar lesion but the bacillus-containing ulcers of leprotic nodules. The improvement was slight and was manifested by slight drying up of the edges and shallowing of the ulcers. In no case did the ulcers become worse.

INCIDENTAL AND SIDE EFFECTS

Kidney.—Because of the constant necessity of considering the effect on the kidneys of such medication in the Culion lepers, the urine of each case was examined four times—before treatment was begun, and at the expiration of each of the three months. No evidence of kidney injury was observed. On the contrary, in two cases the urine, which at the outset contained small quantities of albumin, cleared up; so that in one of them it was not found again, and in the other only at the end of the first month.

Gastrointestinal tract.—Side effects referable to this system were salivation, epigastric heaviness, pain, nausea, and vomiting. Salivation was a frequent symptom complained of by all but two of the cases, but in no case was it marked. Epigastric heaviness was reported by eight of the cases, and epigastric pain by five, of which all but one were among those complaining of heaviness. Neither symptom was severe. Nausea of slight degree was recorded in patients who vomited, seven among the total cases, two repeatedly and five only occasionally.

Reproductive system.—In the majority of the cases there were no symptoms referable to the reproductive system but Cases 1 and 2 always complained of scrotal pains after taking the mixture for four to six days. Case 2 had an epididymo-orchitis probably of leprotic origin; the pain frequently be-

came so intolerable that the medication had to be suspended temporarily.

Reaction.—In the ordinary course of events in leprosy which, broadly speaking, is an afebrile disease, there occur occasional periods of fever noticeable to the patients, usually with disturbance of the leprotic lesions and often with the appearance of new ones. Leprosy treatments are apt to induce such reactions. They occur more frequently in treated than in untreated cases, and are often atypical in their manifestations. In the course of the treatment under discussion 75 per cent of the patients had some such reaction.

In most instances the reaction consisted of simple fever without cutaneous manifestations; four had chills, two only once and two repeatedly. The fever in these simple cases without cutaneous manifestations usually lasted but two to five days, though in a few instances it persisted for a week. It was usually remittent, ranging from 37.5° to 38.7° C., and was sometimes accompanied by other disturbances, as headache, weakness, and body pains.

In four cases exacerbations of the leprotic lesions occurred. In these cases fever lasted sometimes as long as three weeks, with daily remissions, the fever ranging from 37.9° to even as high as 39.9° C. In these, more severe reactions the patient seemed decidedly ill.

Another reaction phenomenon occasionally seen, nerve pain, occurred in three of these cases. One of the three patients with repeated reactions in the cutaneous lesions, a case of apparently pure cutaneous type, suffered intense sciatic pains, repeatedly lasting for about four days. Another, a mixed case, with only one skin reaction, also had sciatic pain. The third case with nerve pain, located in both peroneal nerves, had repeated simple febrile reactions without skin manifestation.

When simple fever occurred treatment was usually suspended temporarily, although in some cases it was pushed until other side effects were observed.

After each reaction with exacerbations of the leprotic lesions the patients appeared to have become weakened, but this was not so with those manifesting only simple fever.

SUMMARY AND DISCUSSION

The present work was undertaken to try out, on cases under our care, the tartar emetic treatment of leprosy advocated by Cawston and Wildish. These authors claim to have obtained

remarkable results, having observed rapid relief of paralyses, drying up of ulcers, and improvement of the general condition.

Thirty patients in the General Hospital of Culion Leper Colony were given tartar emetic intravenously, twelve received antimony wine in cough mixture, and ten antimony wine undiluted. Treatment was given for six months. Twelve other patients received a modified Castellani mixture for three months only.

These patients were mostly males, the majority more than 30 years of age, and the average duration of the disease was about eleven years.

By the intravenous method, using a fresh 1 per cent solution of tartar emetic in water, we were able to give only an average dose of 0.0015 gram of tartar emetic per week. Administered orally in the form of vinum antimonii, the highest dose that could be given was 0.252 gram per week. In the Castellani mixture 0.2275 gram weekly was given.

No improvement of the leprosy itself was noticed in any of the groups. On the whole, the general condition was unfavorably affected. Six of those in the intravenous group and one of those taking the Castellani mixture died during the period of observation. In about 25 per cent of the survivors in the intravenous group and 42 per cent in the Castellani group the ulcers were improved. This improvement was noticed mostly in ulcers of nodules of short duration.

The outstanding side effects noticed were, in those receiving tartar emetic intravenously, injury to the kidneys; and, in the Castellani group, simple fever and the reaction often spoken of as "lepra fever."

A case of extensive ulceration, probably tertiary yaws, injected for about two months, showed marked improvement and none of the ill effect on the kidney that was so noticeable in the lepers.

The most striking observation in this work is the low tolerance of our patients to tartar emetic introduced intravenously. If we compare the small dose that we were able to give with the massive doses that can be given with impunity in the treatment of other affections, it becomes evident how greatly below par are the kidneys of advanced cases of leprosy that we treated. This is not surprising if we consider the strain on the kidneys in these advanced cases. To whatever direct injurious action may result from the disease itself, with its long years of slow progress and its occasional more or less

protracted periods of febrile lepra reaction, is added the burden caused by the multiple, usually infected, lepromatous ulcers, that in many cases persist for years; the constipation so prevalent in our cases; and the numerous drugs usually received by these patients, by injection or otherwise. In the majority of advanced cases the vital function of the skin is doubtless more or less handicapped by extensive cutaneous lesions, and by nervous changes and the atrophy so often prominent in this stage of the disease. The diminution or absence of sweat over the affected parts is a classical manifestation of the disease. Furthermore, in a surprising number of cases, the limited effective portions of the skin are affected by yet other, incidental skin diseases. It is therefore not to be wondered at that the kidneys of advanced lepers are usually damaged. We are made more and more to realize that, in the therapy of this disease, the influence of the drug used on the kidneys must be carefully observed.

According to Levy and Dimmitt [7] tartar emetic should always be cautiously used. These authors have found that the total non-protein nitrogen in the blood is increased by the administration of even a small amount of tartar emetic for a comparatively short period of time. Underhill, Pearce, Ringer, and Salant [8] have observed injury to the kidneys of experimental animals produced by small doses of tartrates.

Pulmonary tuberculous lesions in certain of our cases showed rapid progress under the influence of the treatment. We are inclined to believe that it is an indirect effect through lowering of the resistance of an already run-down patient, thus enabling the disease to progress rapidly, rather than a direct influence on the tuberculous process.

The patients who were under the Castellani mixture received only 2 grams of potassium iodide daily. Wayson [9] used as much as from 6.5 to 13 grams of potassium iodide per day in Hawaiian lepers, and observed breaking down of the leprotic nodules into ulcers which healed, leaving little scars, with restoration of sensation. Salivation, nausea, and vomiting took place at one time or another in the majority of our patients.

[7] Levy, M. D., and Dimmitt, P. S., Am. Journ. Trop. Med. 2 (1922) 569.
[8] Cited by Levy and Dimmitt, loc. cit.
[9] Wayson, James T., Arch. Derm. & Syph. (1921) 248–249. Quoted in Trop. Dis. Bull. 18 (1921) 5, 405.

There were naturally some differences in the side effects produced by the oral and the intravenous routes. Abdominal pain was more frequent and of less serious import in the group receiving the drug by mouth. With reference to the kidneys, injury was produced by the intravenous route while no such effects were seen in the other group. Lepra reaction, marked fever usually with cutaneous eruptions, and simple slight fever occurred almost exclusively in the group taking the modified Castellani mixture. It is probable that this reaction is due to the potassium iodide; this drug is well known to have this effect, and it has sometimes been utilized in diagnosis.

As for the effect on the disease, we have not, with the preparations used, been able to confirm the remarkable results of Cawston and Wildish. This is in agreement with the results of Harper [10] of Makogai, who also failed to obtain any improvement in two cases to whom he gave tartar emetic intravenously to the amount of 2.795 and 2.99 grams in thirty-five and thirty-seven injections, respectively.

We regret that we have not been able to use oscol stibium, which Cawston and Wildish used almost exclusively. However, Clark [11] has found that, by pharmacological tests, there is no marked difference between the action of the "colloidal" preparations tested (one of these being oscol stibium) and the same substance in true solution. Furthermore, this worker believes that the results of Wildish and Cawston are very remarkable when a cure was effected by the injection of from 15 to 40 milliliters of the preparation when 40 milliliters of oscol stibium contains only 0.02 gram of antimony. In other diseases 0.3 to 2.4 grams of antimony was found necessary to produce cures. In fact, simple tartar emetic solution would seem to be more advantageous than oscol stibium in some respects, for while the minimal lethal dose of each for mice is the same, 0.015 gram per kilogram of body weight, the minimal curative dose of oscol stibium in experimental trypanosomiasis in mice is more than twice as large as is that of tartar emetic and, consequently, the ratio between the curative and the lethal doses is reduced.

[10] Harper, P., Brit. Med. Journ. No. 3210 2 (1922) 39. Quoted in Journ. Phil. Is. Med. Ass. 2 (1921) 240.

[11] Clark, A. J., Brit. Med. Journ. No. 3242 1 (1923) 273–277.

CONCLUSIONS

1. Antimony in the form of tartar emetic, vinum antimonii, and Castellani's yaws formula, as we have employed it, appears to be of no real therapeutic value as a means of treating leprosy.

2. Tartar emetic appears to improve some of the ulcerations so commonly found in leprosy but, because of its irritating properties and the fact that it promotes wasting, the use of this drug instead of the more-efficient and less-harmful drugs available is not justifiable.

3. These preparations should be used cautiously in lepers, especially those in the more-advanced stages of the disease. The intravenous medication has, in our experience, proved injurious to the kidneys, which in the majority of these cases showed considerable damage. It also accelerates pulmonary tuberculosis. The Castellani formula tends to excite lepra reaction and is irritating to the stomach.

ACKNOWLEDGMENTS

We are indebted to Dr. H. W. Wade, chief pathologist and acting chief physician, Culion Leper Colony, at whose suggestion this work was initiated, for valuable help given us in the preparation of this paper. We also wish to express our thanks to Dr. C. B. Lara, supervising physician of Clinic 2, for calling our attention to the use of tartar emetic in lepra fever in his clinic and for help in gathering data on the cases so treated.

ELEVENTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

By W. SCHULTZE

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ONE PLATE

The following new species of Philippine Coleoptera are described in this paper:

CERAMBYCIDÆ

Anoplophora asuanga sp. nov.
Anoplophora tianaca sp. nov.
Anoplophora mamaua sp. nov.
Doliops frosti sp. nov.

CURCULIONIDÆ

Eumacrocyrtus canlaoensis gen. et sp. nov.
Metapocyrtus (*Orthocyrtus*) *moorei* sp. nov.
Metapocyrtus (*Orthocyrtus*) *propolitus* sp. nov.
Metapocyrtus (*Metapocyrtus*) *perpulcheroides* sp. nov.
Metapocyrtus (*Metapocyrtus*) *lumutanus* sp. nov.
Metapocyrtus (*Metapocyrtus*) *similis* sp. nov.
Metapocyrtus (*Metapocyrtus*) *annulatus* sp. nov.
Alcides (*Ornatalcides*) *kalinganus* sp. nov.

CERAMBYCIDÆ

Genus ANOPLOPHORA Hope

This genus was founded upon the Assam species *Anoplophora stanleyana* Hope.[1] Newman [2] added the Philippine species *Anoplophora lucipor*, which Westwood [3] redescribed and figured as from the "Manillas." The descriptions given by these authors are rather meager, and the Westwood figure seems to be a rather poor representation of the species in question. The following remarks may aid in differentiating this species from the other Philippine representatives of the genus described in following pages.

[1] Proc. Linn. Soc. London 1 (1839) 43; Trans. Linn. Soc. London 18 (1841) 439, pl. 30, fig. 1.

[2] Entomologist 1 (1842) 275.

[3] Cabinet of Oriental Entomology (1848) 60, pl. 29, fig. 7.

Anoplophora lucipor Newm. Plate 1, fig. 3.

Glossy greenish black, the markings very pale orange, which color mostly changes to creamy white. Antennæ, legs, and underside pale grayish tomentose. The tomentose spots on elytra rather variable in size, particularly the bifid sutural spots. Each elytron with six large dorsolateral primary spots and two smaller spots near base at lateral margin. At suture a series of from three to five bifid spots, which are more or less asymmetrical. All over the surface of elytra a very large number of small and very small spots or dots are scattered between the larger spots. This feature is not present in any of the other species. Prothorax dorsally with a bare discal patch, highly polished, reaching from anterior to posterior margin. The lateral tooth-like projections above also bare and shiny.

Length, 32 to 56 millimeters.

LUZON, Bataan Province, Lamao and Limay (*R. J. Alvarez, C. S. Banks, W. Schultze*).

Anoplophora mamaua[4] sp. nov. Plate 1, fig. 6.

Glossy bluish black; head, prothorax, and underside pale ochraceous tomentose, elytra with bright orange yellow spots. Antennæ and legs pale grayish brown tomentose. Head nearly entirely tomentose except a triangular area at vertex, a longitudinal medial groove extending from front to vertex. Prothorax entirely pale ochraceous tomentose except a narrow parallel longitudinal band dorsally extending from anterior to posterior margin; near the latter it is slightly convergent. The lateral tooth only above near tip slightly bare, sparsely tomentose. Scutellum also tomentose. Elytra scatteredly punctate, the punctures coarser in basal third but finer toward apex. Each elytron with a large orange yellow densely tomentose spot dorsally at base, two smaller spots also basally at lateral margin, and four large spots close to lateral margin, the apical one of which is somewhat triangular. At suture three bifid spots, the largest located before the middle, the smallest at about apical fourth. Behind dorsal basal spot usually one or two small spots. Mesosternum and abdominal sternites laterally with small and more densely tomentose orange spots.

Length, 33 millimeters; shoulder width, 10.8.

[4] *Mamau, tianak,* and *asuang* are the names of evil spirits in Tagalog folklore.

MINDORO, Baco River (*my collector*). Type in the collection of the Bureau of Science.

Anoplophora tianaca sp. nov. Plate 1, fig. 8.

Bluish black; head, prothorax, and elytra with white tomentose markings and spots. Head, front to vertex, antennæ, and legs sparsely and finely grayish tomentose. Sides of head with an irregular white tomentose spot, the longitudinal medial groove very prominent, vertex of head with scattered coarse punctures. Prothorax with an irregular white tomentose spot dorsolaterally and another at sides, below the toothlike projection. Elytra in apical third very coarsely and densely punctate, the punctures smaller toward apex. Each elytron with eight rather large white tomentose spots, six of which form an irregular longitudinal row and two are marginal spots in basal half. Of the six spots, three are located dorsally in basal half, the other three are more lateral in apical half. No sutural spots present. Underside grayish tomentose; mesosternum, metasternum, and abdominal sternites, except the last, laterally with a white tomentose spot.

Length, 26 millimeters; shoulder width, 9.

PANAY, Calivo (*my collector*). Type in the collection of the Bureau of Science, Manila.

Anoplophora asuanga sp. nov. Plate 1, fig. 7, ♀.

Bluish black; head, prothorax, and elytra with white tomentose markings and spots. Head, antennæ, legs, and underside finely grayish brown tomentose. Front of head white tomentose which diminishes toward base of antennæ; vertex and sides also white. Prothorax with an irregular white dorsolateral patch and a large patch at sides. Dorsally a longitudinal bare and glossy discal patch. The lateral tooth projections and subbasal area finely grayish tomentose. Elytra with a large number of medium-sized and small white tomentose spots forming irregular longitudinal rows. Each elytron with a dorsolateral row of twelve to fourteen primary spots, which are more or less asymmetrical. Along lateral margin another row of smaller spots also variable in number but usually ten to twelve. At suture another irregular series of small spots. Prosternum, mesosternum, and metasternum white tomentose. Abdominal sternites, except the last, with a white tomentose spot laterally.

Male, length, 31.5 millimeters; shoulder width, 10; antennæ, 46. Female, length, 39.5 millimeters; shoulder width, 13; antennæ, 39.

MINDANAO, Surigao Province, Surigao. BUCAS GRANDE (*my collector*). Type in the collection of the Bureau of Science, Manila.

Doliops frosti sp. nov. Plate 1, fig. 10.

Head, prothorax, and elytra dark greenish bronze with pale green tomentose markings and spots. Head with an oblong tomentose stripe on front to vertex. Antennæ, first joint coppery bronze, third blackish tomentose and sparsely setose, fourth with basal half whitish tomentose. Prothorax longer than broad, minutely scatteredly punctate, with an anterior submarginal groove and a strongly pronounced posterior submarginal groove; the interspace between the latter groove and posterior margin broader than anterior interspace. At apical half a broad irregular pale green tomentose transverse band. Elytra near base coarsely irregularly punctured, the punctuation toward apex sparser and finer. Each elytron with a wedge-shaped tomentose subsutural spot at base. Before the middle a large transverse tomentose patch extending from near suture, slightly divergent to lateral margin. In apical third a narrow transverse band, also extending from near suture to lateral margin. Apical fourth with a broad V-shaped marking. Underside sparsely grayish pubescent. Mesosternum, metasternum, and first abdominal sternite with a large pale green tomentose spot laterally, the following sternites with a small spot, except the last. Legs coppery bronze.

Length, 11.5 millimeters; shoulder width, 4.5.

SAMAR, Catarman (*R. L. Frost*). Type in the collection of the Bureau of Science, Manila.

I name this interesting species in honor of its collector, through whose kindness I received a number of insects from Samar Island.

This species bears a truly remarkable likeness to *Pachyrrhynchus latifasciatus* Waterh. The exact locality of the latter species is not known; but, on account of the great mimicry aspect of the two species involved, it seems very probable that *P. latifasciatus* Waterh. was collected by Cuming in Samar Island.

CURCULIONIDÆ

Genus **EUMACROCYRTUS** novum

Related to *Macrocyrtus* Heller. Rostrum slightly longer than broad. Scape of antenna reaching beyond posterior margin of eye. Prothorax with distinct and sharply defined anterior and posterior submarginal groove and a dimplelike depression dorsolaterally. Elytra dorsally slightly flattened, the greatest width in the middle, lateral margins from the middle rather abruptly and strongly convergent toward apex; apical fourth of elytra extending beyond abdomen, forming a mammilla-shaped projection in both sexes. First and second abdominal sternites in both sexes connate, the following three well segmented.

Type species, *Eumacrocyrtus canlaonensis* sp. nov., from Negros, Philippine Islands.

Eumacrocyrtus canlaonensis sp. nov.

Dark brown, almost black, with inconspicuous pale bluish white scale markings. Rostrum dorsally scatteredly punctured, with an indistinct longitudinal groovelike depression extending to front, where it forms a well-pronounced groove; at base an indistinct transverse depression. Prothorax as long as broad, glossy, finely and scatteredly punctured, a minute hair arising from each puncture, the punctures nearly obsolete in the male. A dimplelike depression dorsolaterally, nearer middle than base. At lateral margins an irregular patch of fine bluish white scales. Elytra finely, scatteredly punctured and sparsely granulate in the male, in the female the punctures much coarser and more irregular. Elytra dorsally in both sexes with very fine and evenly scattered scales. The latter toward and at basal and lateral margins gradually increase in size and density and are most strongly pronounced as an irregular broad stripe along basal and lateral margins. The apical mammillary projection slightly longer in the female, in both sexes beset with rather long scattered setæ arising from the punctures, particularly along the connate suture. Mesosternum slightly, metasternum and first and second abdominal sternites in the middle with a large and prominent patch of dense furlike ochraceous pubescence in both sexes. Legs reddish brown, femora irregularly punctured, sparsely setose. Tibiæ, on the underside with a number of small tubercles, moderately setose.

Length, male, 14.5 to 16 millimeters (without rostrum); width, 5.8 to 6.6.

Length, female, 14 to 15.5 millimeters (without rostrum); width, 6 to 6.8.

NEGROS, Occidental Negros, Canlaon Volcano (*Taylor, Banks, Curran*).

Twenty specimens of this very characteristic species that I have examined show considerable variation in the punctures and sculpture of the elytra. The hind femora are slightly longer in the males than in the females.

Metapocyrtus (Orthocyrtus) propolitus sp. nov. Plate 1, fig. 5, ♀.

Glossy dark brownish black, with a few scattered pale blue or whitish scales at sides of prothorax and elytra. Nearly related to *Metapocyrtus politus* Heller. Rostrum with a broad and strongly pronounced longitudinal groove confluent with a sharply defined transverse groove at base, densely but irregularly punctured, the punctures toward apex small, but very coarse toward base; front scatteredly punctured, the longitudinal groove from rostrum continued but sharply defined, almost reaching vertex. Sides of rostrum with a groovelike depression before eyes, reaching antennal scrobe. Prothorax broader than long, the greatest width slightly before the middle, rather uniformly scatteredly punctured. A sharply defined anterior submarginal groove and a posterior submarginal groove. Lateral margins with a few scattered pale blue or whitish scales. Elytra short ovate, with irregular puncture rows, the punctures coarser than in *M. politus* Heller. In the male the elytra regularly sloping toward apex, at the latter uniformly rounded, as in the above species, but in the female the apex of elytra forming a large and prominent triangular projection. The latter is formed by two apical thornlike terminations of elytra which are firmly united but still show a distinct broad groovelike depression dorsally. Anterior margin of elytra in both sexes slightly raised or swollen, at lateral basal angle a few scattered scales and in the middle along margin another scattered swarm of scales. Near apex some very fine and scattered silky white hair arising from the punctures. Sides of rostrum and head and legs also beset with scattered silky white hair. Mesosternum and metasternum laterally with a cluster of white scales.

Male, length, 12 millimeters (without rostrum); width, 5.5. Female, length, 13.5 millimeters (without rostrum); width, 6.

LUZON, Kalinga Subprovince, Lubuagan (*my collector*); Davangan (*A. W. C. T. Herre*). Types in the collection of the Bureau of Science, Manila.

The female of this species is very strikingly different from any related species of the genus on account of the peculiar apical projection.

Metapocyrtus (Orthocyrtus) moorei sp. nov.

Glossy black, prothorax and elytra with large golden green metallic scale patches. Rostrum densely punctured, the punctures in apical half small, in basal half coarse and irregular. Basal half with a strongly pronounced somewhat rectangular depression bearing mostly a patch of scales. A distinct dorsal cross groove at base separating rostrum from front. The latter sparsely punctured and with a fine longitudinal median groove. Sides of head with a scale spot below eye. Prothorax slightly broader than long, uniformly scatteredly punctured with an anterior submarginal scale stripe, a large irregular scale patch in the middle toward each side, and an oblong patch at each lateral margin. Elytra ovate, with rather irregular rows of fairly coarse punctures. Each elytron of male with two large scale spots at base, three others at the middle of which an oblong marginal spot extends toward apex, and a series of three or four irregular spots at apical third. In female, and sometimes in male, the two basal spots are confluent, forming a broad crossband; the spots at apical third also confluent, forming a large more or less triangular patch, which extends from first row of punctures laterally to margin. Apex of elytra with a few whitish setæ. Metasternum and first abdominal segment laterally with a large scale spot. In male mesosternum and metasternum in the middle with a rather dense patch of fine setæ. Femora in both sexes in apical part with a large patch or swarm of scales. Tibiæ and tarsi strongly setaceous.

Male, length, 12 millimeters (without rostrum); width, 5. Female, length, 14 millimeters (without rostrum); width, 6.5.

MINDANAO, Lanao Province, Dansalan, April 21, 1920 (*A. Moore*). Types, male and female, in the British Museum.

Four specimens of this species were forwarded to me by the British Museum for determination. I take pleasure in naming this species for its collector, Dr. A. Moore.

Metapocyrtus (Metapocyrtus) perpulcheroides sp. nov. Plate 1, fig. 11, ♂.

Black, moderately glossy; prothorax and elytra with metallic coppery or greenish golden scale spots. In general form very similar to *Metapocyrtus pseudomonilifer* Heller. Rostrum strongly rugose, separated from front by a deep and well-pronounced transverse groove. In basal half a triangular depression, with an indistinct longitudinal groove. Lateral margins of the depression forming slightly raised ridges. Front sparsely and scatteredly punctured, with a sharply defined medial groove and a small bifid scale spot. Sides of head below eye also with a small scale spot. Prothorax broader than long, subspherical, finely and scatteredly punctured; in male, prothorax relatively larger than in female. A well-pronounced anterior submarginal groove and posterior submarginal groove. Dorsally a medial longitudinal groove arising behind anterior submarginal groove and terminating before posterior submarginal groove. Dorsolaterally at anterior margin an irregular scale spot, more or less confluent dorsally in the middle and continued as an irregular marginal stripe laterally. At posterior margin toward each side a large roundish scale spot and some scattered scales laterally along margin. Sides with another scale spot above anterior coxæ. Elytra short ovate, very irregularly striate-punctate. Each elytron with three irregular scale spots at base, four or five more or less confluent spots in the middle forming a transverse row, an oblong spot behind the middle at margin, three other spots forming a transverse row at apical fourth, and another spot near apex. Spots uniform metallic coppery or greenish golden. Mesosternum and metasternum laterally with a scale patch. Femora with a scale ring band near apex.

Male, length, 12.5 millimeters (without rostrum); width, 6. Female, length, 11.8 millimeters (without rostrum); width, 6.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*). Types in the collection of the Bureau of Science, Manila.

This species is remarkable for its extreme likeness to *Pachyrrhynchus perpulcher* Waterh., with which it was collected from presumably the same bushes. The scale markings in this species seem to rub off very readily, since a number of specimens appear uniform black, but upon close examination the markings are distinguishable as dull grayish spots.

Metapocyrtus (Metapocyrtus) lumutanus sp. nov. Plate 1, fig. 9, ♀.

Glossy black, with small pale golden greenish scale spots. Rostrum divergent toward apex, scatteredly punctured, a medial longitudinal groove and pronounced oblong triangular depression in basal half, the lateral margins of which form somewhat raised ridges. Rostrum with a broad transverse groove at base. Front sparsely punctured with a small roundish scale spot, and an indistinct medial groove in the female. Sides of head with a triangular scale spot below eye. Prothorax as long as broad, in the female dorsally sparsely and scatteredly punctate, in the male almost impunctate. Both sexes with an indistinct anterior and a well-pronounced posterior submarginal groove. A roundish spot dorsolaterally at anterior margin, a triangular spot, also dorsolaterally, near posterior margin, and a small roundish scale patch in the middle at each lateral margin. Elytra oblong-ovate, finely and irregularly punctate-striate; each elytron with eleven small roundish spots. Two spots are located near base, one dorsolaterally, the other near anterolateral angle; three other spots form a transverse row near middle; six spots are located at apical half, one of them at margin, one near apex, three at dorsolateral slope, and one subsutural spot at apical fourth. In the female the latter spot is located on a small roundish tubercle which bears a small tuft of short black setæ. Metasternum with a scale patch laterally. Femora with a circumscribing scale band near apex.

Male, length, 9.8 millimeters (without rostrum); width, 4. Female, length, 11.5 millimeters (without rostrum); width, 5.

LUZON, Rizal Province, Mount Lumutan (*my collector*). Types in the collection of the Bureau of Science, Manila.

Metapocyrtus (Metapocyrtus) similis sp. nov. Plate 1, fig. 1.

Head black, prothorax glossy greenish bronze, elytra glossy dark purplish brown with small pale greenish scale spots. In general aspect this species resembles very much *Metapocyrtus lumutanus*. Rostrum minutely and sparsely punctate toward apex, in basal half with a deep and sharply defined longitudinal medial groove. Rostrum obtusely angled at basal junction with front, the medial groove continued on the latter. Prothorax longer than broad, the greatest width before the middle, impunctate. A distinct anterior submarginal groove beset with a fine narrow scale line. Lateral margins in the middle with

a few scales. Elytra very finely and irregularly punctate-striate. Each elytron with twelve small roundish scale spots, two of them near base, five forming a transverse row in the middle, four forming another transverse row at apical third of which the lateral marginal spot is the largest, and one near apex. Metasternum with a scale spot laterally. Legs greenish bronze, with a bluish and purplish sheen.

Female, length, 10 millimeters (without rostrum); width, 4.5.

LUZON, Rizal Province, Mount Lumutan, at about 600 meters (*my collector*). Type in the collection of the Bureau of Science, Manila.

Metapocyrtus (Metapocyrtus) annulatus sp. nov. Plate 1, fig. 4, ♂.

Glossy black, elytra with grayish scale spots. Rostrum slightly divergent toward apex, scatteredly punctured, at base angulately set off from front, basal half with a longitudinal medial groove, which is continued on front, the latter also sparsely and scatteredly punctured. Eyes rather prominently bulging. Prothorax slightly longer than broad, with a narrow anterior and posterior submarginal scale stripe and a roundish spot at lateral margins. Elytra ovate, finely and irregularly punctate-striate. Each elytron with fifteen rather strongly impressed roundish scale spots; one spot at base near margin, four others forming a transverse row in basal fourth the marginal spot of which is very small, three others forming a transverse row in the middle, four large spots forming a transverse row at apical third, an irregular spot near apex, a small subsutural spot behind the middle, and another at apical fourth. Mesosternum and metasternum with a scale patch laterally. Legs relatively long and slender. Tibiæ on underside rather densely setigerous.

Male, length, 9 millimeters (without rostrum); width, 4.

LUZON, Benguet Subprovince, Mount Pulog (*my collector*). Type in the collection of the Bureau of Science, Manila.

The scales on the impressed spots in this species are very small and rudimentary. This specimen was collected together with specimens of *Pachyrrynchus annulatus* Chevr.

Alcides (Ornatalcides) kalinganus sp. nov. Plate 1, fig. 2.

Subcylindrical, glossy metallic coppery, prothorax and elytra with whitish tomentose markings. Rostrum slightly divergent toward apex, apical half finely and regularly punctured dorsally, above antennal base two small callosities or swellings, basal

half irregularly punctured, the punctures coarser at lateral margins. Front with an oblong shallow depression, the latter terminating in a punctiform impression. Vertex of head finely and regularly punctured. Prothorax broader than long, near anterior margin laterally constricted, uniformly and densely punctured, the punctures rather coarse. At posterior margin dorsolaterally an abbreviated narrow whitish tomentose stripe. Elytra very uniformly and finely punctate-striate, the punctures oblong. Each elytron at base with a transverse depression, extending from the knoblike scutellum to humeral angle, basal margin curved and bent upward. At base just behind scutellum an oblong tomentose spot which forms posterolaterally a short oblique spur. Another spot at basal fourth near lateral margin and a slightly curved transverse band behind middle, reaching from suture to eighth puncture row. Prosternum tomentose, mesosternum and metasternum in the middle only. Abdominal sternites, except the last, with a small irregular tomentose patch laterally. The whole underside greenish bronze, densely and irregularly punctured. Apical part of rostrum, antennæ, and tarsi bluish black.

Length, 12 millimeters (without rostrum); width, 5.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*). Type in the collection of the Bureau of Science, Manila.

SYNONYMICAL NOTES ON PHILIPPINE COLEOPTERA

The cerambycid generic name *Niphonoclea* Aurivillius replaces *Euclea* Newman, *Niphonoclea gloriosa* Schultze (= *N. opulenta* Heller). Heller's footnote [5] referring to *N. pulchella* Schultze [6] is a mistake; furthermore, *N. gloriosa* and *pulchella* Schultze are nearly related but distinct species. *Niphonoclea tagala* subsp. *rufofasciata* Schultze (=var. *tricolor* Heller). *Pachyrrhynchus signaticollis* Schultze (=*P. transversarius* Heller). *Metapocyrtus* (*Orthocyrtus*) *schönherri* Waterh. (= *M. malayanus* Schultze). *Alcides butuanensis* Schultze (= *A. XV-spilotus* Heller).

[5] Tijdschr. v. Ent. 66 (1923) 43.
[6] Deutsche Ent. Zeitschr. (1922) 36, pl. 1, fig. 7.

ILLUSTRATION

[Drawings by W. Schultze.]

Plate 1

Fig. 1. *Metapocyrtus* (*Metapocyrtus*) *similis* sp. nov., × 2.
2. *Alcides* (*Ornatalcides*) *kalinganus* sp. nov., × 2.
3. *Anoplophora lucipor* Newm., natural size.
4. *Metapocyrtus* (*Metapocyrtus*) *annulatus* sp. nov., male, × 2.
5. *Metapocyrtus* (*Orthocyrtus*) *propolitus* sp. nov., female, × 2.
6. *Anoplophora mamaua* sp. nov., natural size.
7. *Anoplophora asuanga* sp. nov., natural size.
8. *Anoplophora tianaca* sp. nov., natural size.
9. *Metapocyrtus* (*Metapocyrtus*) *lumutanus* sp. nov., female, × 2.
10. *Doliops frosti* sp. nov., × 2.
11. *Metapocyrtus* (*Metapocyrtus*) *perpulcheroides* sp. nov., female, × 2.

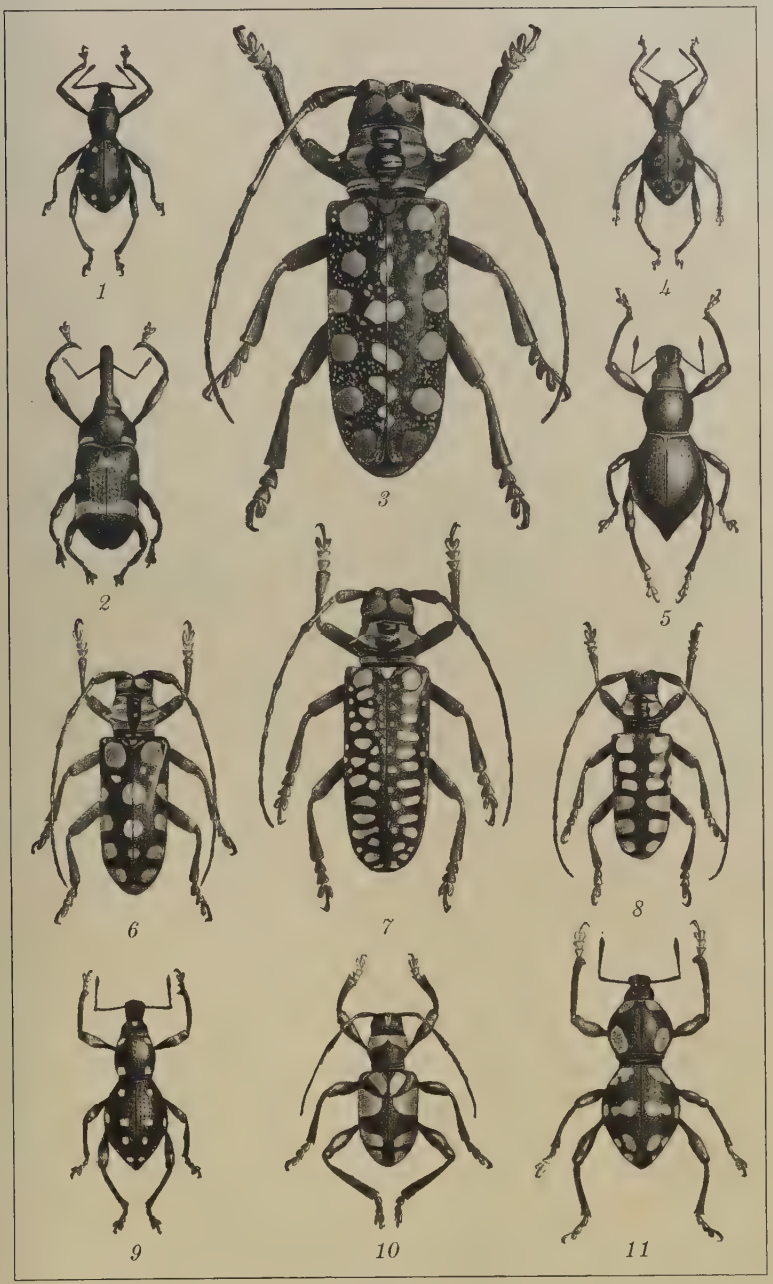

PLATE 1.

A MONOGRAPH OF THE PACHYRRHYNCHID GROUP OF THE BRACHYDERINÆ, CURCULIONIDÆ: PART I

THE GENUS PACHYRRHYNCHUS GERMAR

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NINE PLATES

INTRODUCTION

The Pachyrrhynchides constitute the twelfth group of the second tribe, or subfamily, Brachyderinæ of Lacordaire;[1] they are members of the large family Curculionidæ and represent one of the most highly specialized and remarkable groups of beetles of the Austro-Malayan region. This group of snout beetles has the largest representation in the Philippine Islands and the species number fully one-third of all the curculionids of this region. The peculiar general form of body and the splendidly rich and beautiful scale coloration in manifold designs and markings have attracted the attention of naturalists that have had the opportunity to observe these beetles in their native haunts, as well as of entomologists in general. During my residence of over twenty years in the Philippines and my entomological rambles in various islands of the Archipelago the pachyrrhynchids have always claimed my special attention.

This rather isolated group of beetles offers many interesting problems as well as great difficulties concerning identification due to strong similarities of species in one genus or of species belonging to different genera. Owing to inadequate descriptions, particularly by some of the early writers, it seems advisable to treat the group in monographic form with full and detailed descriptions. The large amount of correctly localized material of this group at my disposal seems to be adequate for this undertaking.

I wish to express here my sincere thanks to all the friends who have collected and contributed material pertaining to this

[1] Hist. Nat. Insectes. Genera Coleopt. 6 (1863) 27.

group, particularly to Mr. R. C. McGregor, Mr. M. H. Curran, Mr. Edward H. Taylor, and Dr. A. W. C. T. Herre.

I am well aware that, in many instances, it is difficult to recognize a certain species even from a good description, particularly in such genera as *Pachyrrhynchus* and *Metapocyrtus*. In order to eliminate the difficulties in this respect and to prevent errors of misinterpretation of known species in the future, I consider it essential to give good illustrations of all species as far as possible. All the original drawings, with the exception of Plate 8,[2] have been made by myself.

This, the first part of my paper, treats of the genus *Pachyrrhynchus*, and it is hoped to deal with the other genera in subsequent parts.

All the Philippine representatives of this group are found in localities which have a rather rich tropical vegetation. Favored localities are rather open, mixed forests with a dense undergrowth along rivers and ravines or on ridges and mountains. Most species are found in such localities on the smaller trees, bushes, shrubs, or ferns. Not a single species is known to feed on any strictly cultivated plant. *Pachyrrhynchus orbifer* Waterh. is found in Luzon (Ilocos Norte and Kalinga Provinces), sometimes in very large numbers, on one of the Euphorbiaceæ, *Jatropha curcas* Linn. (physic nut). This is a naturalized plant in the Philippines, which is found in a semicultivated stage, and is used by Filipinos as fish poison. Whether or not *P. orbifer* actually feeds on this plant I am unable to say. Relatively few species are found in the lowlands; if they do occur there, such localities are mostly spurs or low ridges which are really terminations of some mountain range. By far the larger number of species is found in mountain regions between 500 and 2,000 meters altitude. Because of the large percentage of species found in the central and northern parts of Luzon, it seems probable that the picturesque and little-explored mountainous district between 16° and 18° north latitude was the center of dispersal of the pachyrryhnchids or is the region in which they originated. Details concerning their general distribution are given farther on in this paper. In northern Luzon more than in any other island of the group a greater diversity of genera as

[2] I wish to express again my thanks to Prof. K. M. Heller, of Dresden, who kindly assembled the specimens for Plate 8 and secured the services of Mr. Max Böhme for drawing it. Plates 7, 8, and 9 will be published with the conclusion of this part.

well as species were developed. It is assumed that by an adaptation in conformity to special surroundings and environment their peculiar features of development were brought about; geographic and climatic factors have undoubtedly played the most important parts in bringing about such extraordinary developments. In the pachyrrhynchids the soft wings are absent and the elytra are firmly united at the suture. These characters may have been brought about as the direct results of geologic changes at comparatively very ancient times, due to isolation or island formation. Analogous conditions and similar results are found in the insect fauna of other island regions.[3]

I assume that during a very early period, at a time when the land masses which now form the Malay Archipelago were still connected with each other but already disconnected from Formosa, one or probably several ancestral forms of the pachyrrhynchids were distributed over the regions comprising the Philippines, possibly the Moluccas, and the regions around New Guinea. At a later period, and after the land masses had been transformed into islands, the power of flight in these beetles became of secondary importance, or it may have been a direct handicap on account of peculiar physical conditions, such as torrential rains together with heavy winds and storms in these regions. As the result of a combination of such factors wingless forms slowly developed. Later, as a result of the inability of these beetles to fly, the possibilities of traveling great distances became still more limited, and a relatively large number of species developed in the mountainous regions, where evident upheavals and changes of contour occurred in the past due to extraordinary volcanic and other ordinary physical actions. In the large islands most species are found in very limited areas, such as well-defined mountain ranges, certain valleys, and isolated mountains. Other species are found exclusively on small islands, such as Catanduanes, Polillo, Bucas Grande, and Siargao. A very few species range over a relatively large territory; for example, *Pachyrrhynchus orbifer* Waterh., which is found over the entire northern part of Luzon, but according to each particular locality is modified into hundreds of varieties and local forms. Another example is *P. moniliferus* Germ., which is found in the typical form and several very pronounced varieties in Luzon and has subspecies in Mindoro, Polillo, and the Catanduanes. Instances where a certain species is found in several

[3] Wallace, Island Life (1881) 276.

islands of the group are really rare exceptions. More detailed records of these facts are given under General Distribution.

BIOLOGY OF THE PACHYRRHYNCHIDES

Very little is known concerning the biology of the pachyrrhynchids; I have been able to discover the young stages of only one species, *Pachyrrhynchus confusus*. This species is very common in the swamp regions [4] at the foot of Mount Maquiling in Laguna Province, Luzon, near the town of Los Baños. This fresh-water swamp is an extension of the large lake Laguna de Bay. It is overgrown by a mass of coarse grass, shrubs, and bushes, and also by a heavy growth of a peculiar fern, *Acrostichum aureum* Linn. The water in the swamp varies in depth from a few centimeters to half a meter or more at certain times. *Pachyrrhynchus confusus* feeds on this fern. Adult specimens are common during the entire year and seem to be rather long-lived since at any time some specimens with soft elytra, others with hard elytra of fresh appearance, and still others of old worn appearance are found together climbing about on the fern and on other plants in the swamp. The larvæ were found feeding in the soft parts in the older, lower part of the trunk or caudex of the fern, which consists of alternating soft and very hard tissues. Their burrows are very short. Not more than two larvæ were found in any one plant. The larvæ are oblong and of rather uniform diameter.

The pupa was usually found in a crude pupal chamber near the exterior part of the trunk. In general appearance the pupa is rather elongate. The anterior margin of the clypeus and the sides of the head are beset with a few bristles. The mesothoracic and metathoracic segments dorsad, somewhat laterad, are beset with two thornlike tubercles. The abdominal segments are also beset with a series of fleshy tubercles bearing a few short bristles. The anal segment has, dorsolaterally, a more projecting tubercle and several smaller ones, each bearing a long bristle. The adults feed on the leaves of the fern, starting at the edges, and usually devour an oval piece about 2 centimeters long. *Pachyrrhynchus confusus* has the same habit as its allies; namely, the beetles, in climbing about and being approached, at first try to hide by crawling on the underside of the leaf or on the reverse side of the stem. On being approached very closely they instantly drop to the ground and remain mo-

[4] Schultze, Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10, 11, should be corrected to read *P. confusus* Schultze, op. cit. 23 (1923) 78–81.

tionless for some time. In the dense undergrowth it is very difficult to rediscover the beetle, since the coloration of this species, as well as that of most of its allies, blends well with the surrounding underbrush.

In its food habits as described above *Pachyrrhynchus confusus* may represent an exception and, therefore, no definite conclusions should be drawn with reference to other species of pachyrrhynchids and their food plants, since I suspect, from circumstantial evidences, that some species are root feeders. The beetles of this group are found mostly crawling about on the leaves and twigs of plants and their legs are especially adapted for climbing and obtaining a good grip. The appearance of the beetles in walking is spiderlike, particularly so on account of their peculiar markings. The whole structure of the body of all pachyrrhynchids is extremely hard and solid, in fact so solid that one may step on such a beetle lying on the ground in the forest without injuring it. The unusual hardness of the body of these insects seems to be intended as a protection against injury from falls, or from other accidents which may occur during the usual heavy and violent seasonal rains and storms. During such torrential rains many small and swift brooklets are formed, particularly in mountainous districts. Since these beetles are usually exposed and do not seem to hide during rains, they are knocked to the ground or into the water at such times. When this occurs the hard body of the insect with the united and inflated elytra seems to act as a float, since the abdomen only partially fills the strongly convex and connate elytra. In order to inform myself in this respect I performed an experiment by placing four living specimens of *Pachyrrhynchus confusus* and one of *P. moniliferus* in separate glass jars containing water. All of them floated on the surface and it was plainly evident that the specimens were drawing air under the elytra by raising the apical termination of the abdomen above the surface of the water. Up to six hours after being placed in the water all were still alive and floating about. After twelve hours, one specimen of *P. confusus* was still afloat and very lively, another was afloat but dead; still another, which was on the bottom, showed slight signs of life and recovered very soon after being taken out. The other specimens were dead on the bottom. Under natural conditions the time of floating would not need to be anywhere near as long as this because the beetle would surely meet some object to cling to in less time than that utilized in the experiment.

The general color of body and elytra in the majority of pachyrrhynchid species is black; in some cases dark blackish blue, or dark glowing red, dark green, or dark brown. Certain species show very pronounced sculptural characters, such as grooves on the elytra, as in *Pachyrrhynchus pinorum* Pasc.; most other species of this genus have the elytra mostly punctate-striate and the color patterns only somewhat impressed on the surface. In most species of such other genera as *Metapocyrtus, Pseudapocyrtus,* and *Apocyrtus* the sculptural differences are more strongly pronounced, especially on the prothorax. The color patterns of the pachyrrhynchids consist of colored chitinous callosities, scalelike hair, or mainly scales which are mostly roundish or lentil-shaped, varying in size. The colors of the markings are many, although mostly pale green or blue or bright red as in *Pantorhytes;* some are metallic golden green, or with a brilliancy like precious stones, as in *Pachyrrhynchus gemmatus* or *P. taylori.* In most species the color markings decrease in beauty after death due to post-mortem changes. Light pale blue colors often change to pale greenish white. The striking opalescence of the scale spots in certain species mostly disappears after death. Also, the peculiar brilliancy of the scale markings is reduced in intensity after death and in some instances disappears entirely.

The form of the body of the species of the different genera of the pachyrrhynchids is rather variable. The rostrum is as a rule relatively short and broad, the prothorax is subglobular or subcylindrical, and the elytra are mostly ovate. The general forms of body as outlined above apply particularly to the genera *Pachyrrhynchus, Pantorhytes,* and *Sphenomorpha.* In the species of the genus *Eupachyrrhynchus* the elytra are rather short, broad, and somewhat flattened dorsally. In *Macrocyrtus* the elytra are very much oblongish and strongly flattened dorsally; the secondary sexual characters are mostly present at the apical termination of the elytra. In the male this part of the elytra is evenly rounded, in the female the apical ends of the elytra are more or less divergent. The elytra of the species of *Proapocyrtus* are rather short, dorsally flattened, and laterally abruptly declined in an acute angle, while in *Apocrytus* the elytra are more inflated and subspherical. In the species of *Pseudapocyrtus* the elytra are relatively very short, strongly inflated, most nearly subspherical, and at the apical termination laterally depressed, ending in an abrupt projection, particularly in the female. In species of *Nothapocyrtus* the elytra are mostly

ovate, not strongly inflated, and somewhat depressed dorsally. The greatest diversity of body forms, particularly of such parts as the rostrum and the elytra, are found in species of *Metapocyrtus*. In most of the species of that genus secondary sexual characters are very pronouncedly manifest, mainly in the differently shaped elytra, in some species in a truly remarkable degree. In species of *Homalocyrtus* the form of the elytra of the two sexes is also very much differentiated. In the males the elytra are mostly divergent toward the apex, in the female more uniformly oblong-ovate. Some time ago I carried out some comparative studies on the penis structures [5] of a large number of species of different genera of the group. The following were examined:

	Species.
Pachyrrhynchus	27
Metapocyrtus	3
Pantorhytes	1
Pseudapocyrtus	2
Apocyrtus	1
Homalocyrtus	3
Macrocyrtus	2

The studies showed very clearly, with particular reference to species of the genus *Pachyrrhynchus*, that this organ is a hard chitinous tube of variable length and form, according to the species, the color pale translucent brown to dark chestnut brown or black. In general aspect the penis forms, with reference to generic characteristics, exhibit marked differences.

Concerning the value of this organ as a medium for the determination of a species, I consider it an excellent criterion, since I found it to be uniform in shape in as many as ten specimens of a species that I examined in this respect. Furthermore, a rather great diversity of form of this organ is found among the different species of a given genus. In generic differences in the structure of this organ certain species of *Pachyrrhynchus* appear closest in similarity to species of *Pantorhytes* and *Metapocyrtus;* but all three of these genera are in great contrast in this respect to species of the genera *Macrocyrtus, Pseudapocyrtus, Apocyrtus,* and *Homalocyrtus.* In order to demonstrate the specific characteristics of the penis structure and the value of this organ as a medium for identification among different species of the genus *Pachyrrhynchus,* figures of 26 species are given. (Plate 3, figs. 13–38.)

[5] Philip. Journ. Sci. 21 (1922) 592, pls. 3 and 4.

MIMETIC RELATIONS

Another very peculiar and outstanding feature of the Pachyrrhynchides is the remarkable resemblance in color and markings of species found together in the same locality or on the same plants, but belonging to different genera of this group, or to different families of Coleoptera, or to different orders of insects. In most instances the color patterns of the different species occurring together and resembling each other are of course not exactly the same, but the general appearance and behavior of the beetles produce the effect of extreme similarity. Table 1 gives a number of such species which were actually observed occurring together.

I have endeavored to ascertain a reasonable explanation for the value that attaches to the similarity in color patterns of different species of Pachyrrhynchides apparently manifesting certain mimicry relations to each other as demonstrated above. Concerning the question of protective mimicry, we assume that the species serving as model is a more abundant form, qualified and protected by special features and logically older than the other species or counter-likeness—the mimetic or unprotected, more recent, and scarcer form. Referring to the species in the list the outstanding fact is that most of those that exhibit such great resemblance to each other are pachyrrhynchids belonging to different genera of this group. All of them have the same general hardness and in none was I able to detect any special glands or other organs which would serve as a protective device. By actual experience in collecting them I observed that in nearly all cases the species belonging to the genus *Pachyrrhynchus* were commoner than were those belonging to the genera *Metapocyrtus* and *Macrocyrtus*, the last named being much scarcer. So far, I have been able to obtain but little evidence concerning the natural enemies of these beetles, such as birds, etc., although I am inclined to believe that they do have some rather specific natural enemies. Perhaps their extreme hardness and compactness is in itself the protective feature that prevents most birds from eating them.

Frogs and toads are to be considered as general enemies of the Pachyrrhynchides, of other Coleoptera, of all other orders of insects, as well as of spiders, centipedes, and even small crustaceans. In August, during the rainy season of 1923, Mr. Edward H. Taylor collected a number of frogs and toads in and around Baguio, Benguet Province. Through his kindness I was able to examine the stomach contents of twelve large frogs,

TABLE 1.—*Species of Pachyrrhynchus occurring together with other pachyrrhynchids or other Coleoptera of mimetic appearance or vice versa.*

Pachyrrhynchus species.	Occurring with—	Locality.
Pachyrrhynchus venustus Waterh. (= *virgatus* Schultze)	*Metapocyrtus* (*Orthocyrtus*) *schoenherri* Waterh. (= *malayanus* Schultze)	Mindanao, Surigao, Surigao.
Pachyrrhynchus venustus insulanus Schultze	*Metapocyrtus schoenherri atratus* Schultze	Siargao and Bucas Grande Island.
Pachyrrhynchus ardentius Schultze	*Metapocyrtus* (*Orthocyrtus*) *insulanus* Schultze	Siargao Island.
Pachyrrhynchus signatus Schultze	*Doliops siargaoensis* Schultze	Siargao Island.
Pachyrrhynchus speciosus Waterhouse	*Doliops geometrica* Waterh. and *Metapocyrtus* (*Orthocyrtus*) *ornatus* Schultze.	Mindanao, Surigao, Surigao, and Dinagat Island.
Pachyrrhynchus postpubescens Schultze	*Doliops multifasciata* Schultze	Mindanao, Bukidnon, Lindabon.
Pachyrrhynchus jugifer Waterhouse	*Metapocyrtus panayensis* Schultze	Panay, Capiz, Mount Macosolon.
Pachyrrhynchus congestus Pascoe	*Metapocyrtus congestus* Schultze and *Alcides schuetzei* Schultze.	Luzon, Benguet, near rest house, kilometer 30.
Pachyrrhynchus orbifer Waterhouse	*Metapocyrtus orbiferoides* Schultze and *Doliops imitator* Schultze.	Luzon, Ilocos Norte, Mount Nagapatan.
Pachyrrhynchus reticulatus Waterhouse	*Metapocyrtus* (*Orthocyrtus*) *pachyrrhynchoides* Heller and *Doliops pachyrrhynchoides* Heller.	Luzon, Laguna, Paete, and Mount Banahao.
Pachyrrhynchus gloriosus Faust	*Metapocyrtus* (*Orthocyrtus*) *bakeri* Heller	Luzon, Laguna, Paete, and Mount Banahao.
Pachyrrhynchus igorota Schultze	*Macrocyrtus trivittatus* Schultze	Luzon, Benguet, Mount Pulog.
Pachyrrhynchus erosus Schultze	*Metapocyrtus interruptolineatus* Heller	Luzon, Benguet, Atok.
Pachyrrhynchus erichsoni Waterhouse	*Doliops curculionides* Waterhouse	Mindanao, Surigao.
Pachyrrhynchus taylori Schultze	*Macrocyrtus kalinganus* Schultze	Luzon, Kalinga, Balbalan.
Pachyrrhynchus basilanus Heller	*Doliops basilana* Heller	Basilan Island.
Pachyrrhynchus perpulcher Waterhouse	*Metapocyrtus perpulcheroides* Schultze	Luzon, Kalinga, Pinukpuk.
Pachyrrhynchus annulatus Chevrolat	*Metapocyrtus annulatus* Schultze	Luzon, Benguet, Mount Polis.
Pachyrrhynchus samarensis sp. nov.	*Metapocyrtus* (*Sphenomorphoidea*) *laevicollis* Waterhouse.	Samar, Catarman.

three medium-sized frogs, and two toads. The results of my examinations are here reported.

LARGE FROGS, RANA MAGNA STEJNEGER

Specimen 1.—Coleoptera: Two Scarabæidæ, *Catharsius aethiops* Sharp; 1 Melolonthidæ, *Apogonia* sp. ?; 1 Tenebrionidæ, *Uloma* sp. ?; 1 Lucanidæ, *Aegus* sp. ?; other Coleoptera, several fragments. Lepidoptera: Geometridæ, 2 larvæ.

Specimen 2.—Lepidoptera: About 20 caterpillars. One centipede.

Specimen 3.—Coleoptera: One Carabidæ, *Thlibops integricollis* Heller; other Coleoptera, several fragments. One spider.

Specimen 4.—Coleoptera: One Melolonthidæ; fragments of other Coleoptera. Hemiptera: One large Reduviidæ. One Forficulidæ. Two stones.

Specimen 5.—Coleoptera: One Melolonthidæ, *Apogonia ?*. Lepidoptera: Several caterpillars of Noctuidæ. Two medium-sized spiders. One centipede (*Scolopendra ?*). Several large earthworms.

Specimen 6.—Coleoptera: Two Curculionidæ, *Pachyrrhynchus pinorum* Pascoe; 1 *Heteroglyma alata* Heller. One small crab. One stone.

Specimen 7.—Coleoptera: Two Melolonthidæ, *Apogonia* sp.; 1 Curculionidæ, *Macrocyrtus nigrans* Pascoe (nearly perfect). Hemiptera: Several fragments of aquatic species, Nepidæ?.

Specimen 8.—Coleoptera: One Scarabæidæ, *Catharsius aethiops* Sharp; 1 Carabidæ; 2 Curculionidæ, *Macrocyrtus nigrans* Pascoe. Fragments of Locustidæ, Acrididæ, and water Hemiptera.

Specimen 9.—Coleoptera: One Elateridæ; 1 Melolonthidæ, *Apogonia* sp. ?; Cetonidæ, elytra of *Protaetia* sp. Lepidoptera: Fragments of caterpillars. Hymenoptera: One large black Formicidæ.

Specimen 10.—Coleoptera: Four Melolonthidæ, *Apogonia* sp. ?. Fragments of Orthoptera. One small centipede.

Specimen 11.—Coleoptera: Elytra of Cerambycidæ; 1 Chrysomelidæ, *Aulacophora* sp. ?. Orthoptera: Fragments of Phasmidæ.

Specimen 12.—Orthoptera: One Gryllidæ; fragments of Acrididæ.

MEDIUM-SIZED FROGS, RANA LUZONENSIS BOULENGER

Specimen 1.—Coleoptera: Fragments. One large spider.

Specimen 2.—This frog evidently had been feeding near a light. Coleoptera: Six small Carabidæ; fragments of other Coleoptera. One earthworm.

Specimen 3.—Orthoptera: Fragments. Hymenoptera: Several medium-sized ants.

TOADS, KALOULA RIGIDA TAYLOR

Specimen 1.—Hymenoptera: Formicidæ, about 80 large black ants, *Crematogaster* sp. ?.

Specimen 2.—Coleoptera: Carabidæ, one nearly entire insect and 6 elytra; Chrysomelidæ, fragments; Scarabæidæ, 2 *Onthophagus* sp. ?; 4 Curculionidæ, *Metapocyrtus* sp. ?. Hymenoptera: Formicidæ, about 50 medium-sized ants and fragments. Hemiptera: Fragments of small insects.

As to the marked resemblance among species belonging to different genera of Pachyrrhynchides, I am almost forced to the conclusion that this is due to the existence of similar conditions in respect to food, surroundings, and environment. The unusual hardness of these beetles seems to have developed more as a protection against accidents due to the usual heavy rains and storms in the regions inhabited by them. The superficial resemblance to spiders I consider as rather incidental. Concerning the different species of cerambycids involved in the above questions, all of which belong to the genus *Doliops* and seem to be very rare, the facts again seem rather to substantiate and emphasize the theory that the hardness of the Pachyrrhynchides is a protection against certain enemies and that the color and pattern resemblance in the rare *Doliops* species developed as a protective device. The *Doliops* species, like most cerambycids, are of moderate hardness. It is well known that many species of this family form the food of many birds, such as woodpeckers, etc.; so it would seem that, if a species of cerambycid resembled a species of beetle not suitable for food, the resemblance would be a protection. I may mention that several cerambycids are known from the Philippines aside from those mentioned above, which bear a strong resemblance to certain surroundings, for example, *Xylorrhiza adusta* Wiedem., which resembles bark; others, like *Ephies coccineus* Gahan, which resemble some other beetles, as Lycidæ, the latter known to be obnoxious for some reason or another.

The rather frequent association of beetles of the above-named groups has been so impressive, to myself as well as to others, that in collecting a certain pachyrrhynchid or *Doliops* we suspected the existence near by of one or the other parallel form. In several instances we were rewarded by finding this true.

The cricket *Scepastus pachyrrhynchoides* from Luzon, described by Gerstäcker,[6] which bears such an extraordinary resemblance to a certain *Pachyrrhynchus* species, I should suppose from the description resembles *P. confusus;* I am unable to add anything about this species. I believe it has not been reported or collected since the time of Semper, its discoverer; it appears to be a very rare insect.

I hope to have shown that the status of the questions concerning the mimicry relations of the pachyrrhynchids is still

[6] Stett. Ent. Zeitg. 24 (1863) 408, pl. 1, figs. 3, 3*a*.

problematic, and further research and much more actual observation in the field are required.

GENERAL DISTRIBUTION OF THE PACHYRRHYNCHIDES

The pachyrrhynchids in their geographic distribution contrast greatly to the other curculionids, all other Coleoptera families and, in a general way, also nearly all other insect orders, even mammalians, reptilians, fishes, and plants, in their almost complete alliance with those of the eastern Malaysian and Papuan regions. This is particularly noteworthy and of great significance since the general alliance of the Philippine fauna and flora is rather uniformly mixed; that is, their alliance is with both the western Malaysian and the eastern Malaysian regions.

The pachyrrhynchids are even rather restricted in their general distribution; by far the largest number of representatives are found in the Philippine Islands. I consider it certain that surprisingly large numbers of species of pachyrrhynchids will yet be discovered in the vast unexplored or only superficially known parts of the Philippines, particularly in the following regions: The Batanes and Babuyanes groups of islands between Formosa and Luzon, on all of which only very limited collecting has been done; northern Luzon, in the eastern mountain ranges, near Mount Moises; Mindoro Island; most of the Visayan islands; and central Mindanao.

Actual entomological collecting has been carried on in practically all of the islands comprising the Philippine group. Much more extensive collecting by many different persons has been done in Luzon (with the exception of the areas above indicated) than in any other island.

The distribution of the respective genera and species of the Pachyrrhynchides is as follows:

1. *Pachyrrhynchus* is represented by about 85 species, of which 81 are found exclusively in the Philippines and only 4 outside; namely, 1 in the Riu Kiu Islands, and 3 in the Moluccas (Sangir, Ternate, and Halmahera). By far the larger number of Philippine species is found in Luzon, and on this island the larger number is found in the mountainous districts of the northern half. Of the other Philippine species about 14 are found in Mindanao and the rest are scattered over various islands.

2. *Eupachyrrhynchus*[7] Heller contains only 1 species (*E. su-*

[7] *Eupachyrrhynchus hieroglyphicus* Schultze must be placed in the genus *Macrocyrtus* Heller.

perbus Heller), the exact locality of which is not known, but I suspect it was collected in northern Luzon.

3. *Macrocyrtus* Heller is represented by 12 species, all of which are found in northern Luzon.

4. *Eumacrocyrtus* Schultze, with only 1 species, Negros.

5. *Proapocyrtus,* Schultze, with only 1 species, Panay.

6. *Apocyrtus* Erichson, with 2 species, Luzon.

7. *Pseudapocyrtus* Heller, with 8 species, 6 of which are found in Luzon, the others in neighboring islands.

8. *Nothapocyrtus* Heller, with 7 species, all of which are found in northern Luzon.

9. *Metapocyrtus* Heller contains about 118 (156) species and is found in practically all the islands of the Philippines, but about 40 per cent of the species are found in Luzon.

10. *Homalocyrtus* Heller contains at present 8 species (16, see Table 2) most of which are scattered over the various islands of the Philippines.

11. *Pantorhytes* Faust, with about 20 species, which are found in the New Guinea region.

12. *Sphenomorpha* Behrens contains about 9 species, of which 7 are found in the New Guinea region and 2 only in the Moluccas.

13. *Apocyrtidius* Heller, with 1 species, is found only in Borneo.

In order to demonstrate more clearly the general distribution of genera and species of pachyrrhynchids involved I have prepared Table 2;[8] the particular distribution of species and subspecies of the genus *Pachyrrhynchus* is given in Table 3.

Table 2 shows clearly that the center of dispersal of the pachyrrchynchids is the Philippine Islands, particularly Luzon. Table 3 shows localities of 85 species and 13 subspecies of *Pachyrrhynchus.*

[8] The numbers of species as indicated in Table 2 for the large genus *Metapocyrtus* and the genus *Homalocyrtus* are only tentative or approximate for demonstration purposes. The actually known number of valid species of *Metapocyrtus* at the present time is about 104, for several of which the exact locality is not known. In the collections at my disposal I have about 156 species of *Metapocyrtus* from the Philippines, which fact indicates how necessary a revision of this genus is before any definite conclusions can be reached. The genus *Homalocyrtus* contains at the present time about 8 known species but among my material of this genus I have 16 species from the localities as indicated in Table 2. Therefore, all figures in Table 2 with an x indicate that at least the given number of species is known from that locality, irrespective of whether they have been determined or are new.

TABLE 2.—*Showing the approximate distribution of the pachyrrhynchids (Curculionidæ).*

[An x indicates that at least the given number of species is known from the locality.]

Genus.	Riu Kiu Islands, 1 species.	Philippine Islands, 298 species and subspecies.																								
		Batanes.	Babuyanes.	Luzon.	Polillo.	Catanduanes.	Mindoro.	Ticao.	Romblon.	Sibuyan.	Masbate.	Panay.	Samar.	Bilran.	Leyte.	Negros.	Cebu.	Bohol.	Dinagat.	Siargao.	Bucas.	Mindanao.	Samal.	Basilan.	Palawan.	Busuanga.
Pachyrrhynchus	1	2	2	55	4	4	2	----	----	----	----	1	7	----	2	----	----	1	1	3	4	14	----	1	----	----
Eupachyrrhynchus	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Macrocyrtus	----	----	----	12	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Eumacrocyrtus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----
Proapocyrtus	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Apocyrtus	----	----	----	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pseudapocyrtus	----	----	----	6	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Nothapocyrtus	----	----	----	7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Metapocyrtus	----	2x	3x	63x	7x	3x	6x	1x	2x	2x	2x	9x	3x	4x	3x	5x	2x	2x	1x	5x	4x	24x	1x	----	1x	1x
Homalocyrtus	----	----	----	3x	1x	1x	----	----	1x	1x	----	----	1x	----	2x	----	----	1x	1x	1x	1x	2x	----	----	----	----
Pantorhytes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Sphenomorpha	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Apocyrtidius	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Species accredited to locality	1	4	5	149	13	9	8	1	3	3	2	11	11	4	7	6	2	4	3	9	9	40	1	1	1	1

Genus.	Borneo, 1 species.	Moluccas, 5 species.				New Guinea, 27 species.								Total species.	Total subspecies.
		Sangir.	Ternate.	Halmahera.	Batchian.	New Guinea.	Sud East.	Gebe.	Morty.	Fidji.	Woodlark.	Solomon.	New Britania.		
Pachyrrhynchus		1	1	1										85	13
Eupachyrrhynchus														1	
Macrocyrtus														12	
Eumacrocyrtus														1	
Proapocyrtus														1	
Apocyrtus														2	
Pseudapocyrtus														8	
Nothapocyrtus														7	
Metapocyrtus														156	
Homalocyrtus														16	
Pantorhytes						15	1			1	1	1	1	20	
Sphenomorpha				1	1	5		1	1					9	
Apocyrtidius	1													1	
Species accredited to locality	1	1	1	2	1	20	1	1	1	1	1	1	1	319	13

Recapitulation of Table 2.

Philippines, represented by 10 genera containing 298 species and subspecies of which 9 genera are endemic.
Moluccas, represented by 2 genera containing 5 species.
New Guinea, represented by 2 genera containing 27 species.
Riu Kiu Islands, represented by 1 genus containing 1 species.
Borneo, represented by 1 genus containing 1 species; genus endemic.

TABLE 3.—*Distribution of the species and subspecies of the genus Pachyrrhynchus Germar.*

[Species marked x? are placed provisionally in that locality; the exact locality is not known.]

Pachyrrhynchus—	Riu Kiu Islands.	Philippines.																						Moluccas.		
		Batanes.	Babuyanes.	Luzon North.	Luzon South.	Polillo.	Catanduanes.	Mindoro.	Masbate.	Samar.	Leyte.	Panay.	Negros.	Romblon.	Sibuyan.	Cebu.	Bohol.	Dinagat.	Bucas.	Siargao.	Mindanao.	Basilan.	Palawan.	Sangir.	Morotai.	Ternate.
absurdus																			x							
amabilis																					x					
anellifer				x																						
annulatus				x																						
apicatus						x																				
apocyrtoides																					x					
ardentius																				x						
argus				x																						
atrocyaneus																					x					
baluganus					x																					
basilanus																						x				
benguetanus				x																						
bucasanus																			x							
chamissoi																					x					
chlorites			x																							
circulatus							x																			
confusus					x																					
congestus				x																						
subsp. *coerulans*				x																						
subsp. *pavonius*				x																						
subsp. *ocellatus*				x																						
consobrinus				x																						
corpulentus																					x					

croesus
cumingi
decussatus
dohrni
dubiosus
elegans
equus
erichsoni
subsp. eschscholtzi
erosus
forsteni
gemmatus
subsp. purpureus
gloriosus
subsp. abbreviatus
halconensis
helleri
igorota
inclytus
infernalis
jugifer
lacunosus
latifasciatus
libucanus
loheri
torquini
möllendorffi
monilifer
subsp. chevrolati
subsp. stelluliger
morio
moroluensis
multipunctatus
nobilis
ochroplagiatus

TABLE 3.—*Distribution of the species and subspecies of the genus Pachyrrhynchus Germar*—Continued.

Pachyrrhynchus—	Riu Kiu Islands.	Philippines.																							Moluccas.		
		Batanes.	Babuyanes.	Luzon North.	Luzon South.	Polillo.	Catanduanes.	Mindoro.	Masbate.	Samar.	Leyte.	Panay.	Negros.	Romblon.	Sibuyan.	Cebu.	Bohol.	Dinagat.	Bucas.	Siargao.	Mindanao.	Basilan.	Palawan.	Sangir.	Morotai.	Ternate.
orbifer		x		x																						
subsp. *gemmans*				x																						
subsp. *azureus*				x																						
perpulcher				x																						
phaleratus							x																			
pinorum				x																	x					
postpubescens					x																					
pseudoproteus					x																					
psittacinus					x																					
psittaculus											x															
pulchellus				x																						
regius					x					x?																
reticulatus				x																						
subsp. *cruciatus*						x																				
roseomaculatus					x					x																
rufopunctatus																										
rugicollis				x																						
samarensis					x																					
sanchezi		x																			x?					
sarcitis				x																						
schoenherri					x?																x					
schuetzei																					x					
semiignitus																										
semperi																										
signaticollis																										

| | | |

The outstanding features in these tables are that the Pachyrrhynchides at present contain 13 genera with tentatively 332 species, of which the Philippines are credited with 10 genera and 298 species; 9 genera are endemic to the Philippines; and 4 genera are, so far as known, endemic to Luzon. The most noteworthy fact is that the Philippines contain over 89 per cent of the total species known, and that the 8 genera represented in Luzon contain 149 species, or over 44 per cent of the entire pachyrrhynchid group.

SYSTEMATIC CLASSIFICATION AND BIBLIOGRAPHIC NOTES

The first representative of the pachyrrhynchids was made known by Germar [9] in 1824 who established the genus *Pachyrrhynchus* on the species *P. moniliferus*, the specimens of which were collected by Eschscholtz probably on a trip from Manila to the Lake Taal region in Laguna Province, Luzon. In 1834 Erichson [10] founded the genus *Apocyrtus* based on the species *A. inflatus* Erichs. Two other species which the last-named author described at the same time, *A. profanus* and *A. impius* Erichs., were later placed by Heller in the genus *Metapocyrtus*. The Erichson material was collected by Meyen. [11] From 1841 to 1843 Waterhouse [12] made the largest additions of species to both of the above genera, from material collected by Hugh Cuming. [13]

In order to show the possible localities in which Cuming collected his material in the Philippines the following data are quoted: [13]

"Mr. Cuming," observes the author, "the fruits of whose western voyage are so well known, left England on the 26th of February, 1836; he proceeded to the Philippine Islands, by the permission of the Queen Regent of Spain, and aided by powerful recommendations from her government, which opened to him the interior of the islands * * *.

"Mr. Cuming visited the whole group. His longest stay was in the Island of Luzon, fifteen provinces of which were well ransacked by him. In the Islands Mindoro, Negros, Panay, Siquijod [Siquijor], Cebu, Bohol, Camiguing [Camiguin near Mindanao], Mindanao, Leyte, Samar, Capul, Ticao, Masbate, Burias, Temple, Marinduque, Maracavan, and Ramblon [Romblon], he reaped a fine harvest. He left the Philippines in No-

[9] Insectorum species novae aut minus cognitae 1 (1824) 336.

[10] Nova Acta Acad. Caes. Leop.-Carol. Nat. Curiosor. 16 Suppl. 1 (1834) 253.

[11] Reise um die Erde 2 (1835) 192.

[12] Proc. Ent. Soc. London (1841) 18 and 45; Ann. & Mag. Nat. Hist. 8 (1842) 218; 9 (1842) 302; 11 (1843) 247; Trans. Ent. Soc. London I 3 (1841–1843) 310–327.

[13] Ann. & Mag. Nat. Hist. 7 (1841) 226.

vember, 1839, proceeded thence to Singapore and Malacca, and returned to England in June 1840, * * *."

Further references are found on pages 227–233, 335, 506, 543, 560, and 562; and in volume 8, pages 62, 148, 380, 527, 536, and 538.

From the same material Chevrolat [14] described, also in 1841, unfortunately as Behrens correctly remarks, a number of species of the above genera, the greater number of which turned out to be identical with those described by Waterhouse, but the confusion created by Chevrolat due to the rather vague descriptions has not been completely cleared up. Further additions to this group were made in 1845 by Boheman. [15] Aside from the above-mentioned authors the following made further contributions. Eydoux et Souleyet, [16] Guerin-Meneville, [17] Montrouzior, [18] White, [19] Boheman, [20] and Snellen van Vollenhoven. [21] In 1873 Pascoe [22] added some more species from the Philippines as well as from the Moluccas and the New Guinea region; still others were added by Gestro [23] in 1875, Roelof [24] in 1876, Bates [25] in 1877, and Oberthür [26] and Gestro [26] in 1879. Further additions were made by Chevrolat [27] in 1881.

In 1887 Behrens [28] published an excellent analytical revision and gave a very detailed account of the whole group. This author's résumé was also based on rather limited material, although he described in his paper 2 new genera, *Sphenomorpha* Behr. with 3 new species from the New Guinea region and *Cataphractus* Behr. with 1 species from the same region. The last-named genus was eliminated from the pachyrrhynchids by

[14] Revue zoologique (1841) 224–226.

[15] Boheman in Schönherr, Gen. et spec. Curcul. 8 Suppl. (1845) pars 2, 381–398.

[16] Revue Zool. par La Soc. cuvierienne (1840) 266.

[17] Revue Zool. (1841) 216; Mag. de Zool. (1842).

[18] Ann. des sc. phys. et nat. de la Soc. d'Agric. de Lyon, 2 ser. t VII, 1 (1857) 46.

[19] MacGillivray's Narrat. Voy. Rattlesnake, App. 2 (1852) 388.

[20] Vetonsk. Jakttag. K. Svenska Fregatten Eugen. Resa omkr. Jorden 2 (1859) 119.

[21] Tijdschr. voor Entomol. (1864) 168.

[22] Journ. Linn. Soc. 11 (1873) 154.

[23] Ann. Mus. Civ. Genova 7 (1875) 1008.

[24] Bull. Soc. Ent. Belg. 19 (1876) VII.

[25] Trans. Zool. Soc. (1877) 154.

[26] Ann. Mus. Civ. Genova 14 (1879) 562 and 570.

[27] Le Naturaliste (1881) 348, 359, 439.

[28] Stett. Ent. Zeitg. 48 (1887) 211.

Faust [29] and placed with the celeuthetids. Among the material at the disposal of Behrens was that collected by Semper. He considered the peculiar distribution and mimicry of the group at length and made comparisons to certain mimicry analogues among the Lepidoptera of the Amazon River region. After treating the whole group he partially revised and described 7 apparently new species of *Pachyrrhynchus* of a subsection which he designated, in my opinion very inappropriately, as the "Gemmatus-Gruppe." In the redescription of some of the Waterhouse species he created confusion,[30] which it has taken many years to clear up, mainly due to limited material. In 1888 Kraatz [31] described 3 more species of *Pachyrrhynchus,* made some critical remarks on Behrens's work, and placed the species of the so-called "Gemmatus-Gruppe," in a synopsis table. In 1892 Faust [32] erected the genus *Pantorhytes* for several species that had been described as *Pachyrrhynchus* species but which have morphological characters very different from those of the latter genus. As type he designated *P. chrysomelas* Montr. A determination table and synopsis of the genus *Pantorhytes* Faust [33] was given by Heller in 1903 and 1905. In 1908 Heller founded the monotypic genus *Apocyrtidius,*[34] the type being *A. chlorophanus* Heller from Borneo. Finally, in 1912, Heller [35] published his excellent revision of the pachyrrhynchids, particularly those of the Philippine region. For this work the material from the various larger museums of Europe was made available to Professor Heller as well as the material from the Bureau of Science collection. The existing confusion of the group was definitely cleared up and, due to Heller's efforts, the systematic arrangement of the pachyrrhynchids was effected. Heller described in his work 5 new genera, *Eupachyrrhynchus, Pseudapocyrtus, Macrocyrtus, Nothapocyrtus,* and *Metapocyrtus,* and 53 new species, besides several new varieties of Philippine pachyrrhynchids. He divided *Metapocyrtus* into 7 subgenera. Keys are given for all the known genera of the group and for all the Philippine species. Since 1912 about 24 species

[29] Stett. Ent. Zeitg. 58 (1897) 70.

[30] Schultze, Philip. Journ. Sci. 23 (1923) 77.

[31] Deutsche Ent. Zeitschr. (1888) 25.

[32] Stett. Ent. Zeitg. 53 (1892) 193.

[33] Abh. u. Ber. Zool. Mus. Dresden No. 2 (1902–03) 14; Wien. Ent. Zeitg. 24 (1905) 305.

[34] Stett. Ent. Zeitg. (1908) 129.

[35] Philip. Journ. Sci. § D 7 (1912) 293.

and several varieties have been added by Heller,[36] and 56 species and 6 varieties by myself.[37] In 1918 I erected the monotypic genus *Proapocyrtus*, the type of which is *P. insularis* Schultze, and in 1922 I recognized the necessity for the separation of the subgenus *Homalocyrtus* from *Metapocyrtus* Heller, as a well-characterized genus. Recently I described also the monotypic genus *Eumacrocyrtus*.

Key to the genera of Pachyrrhynchides, mainly as given by Heller.

a^1. Rostrum at most with a fine, indistinct, basal cross groove, mostly without the latter, apical half dorsally mostly bulging or swollen.

b^1. Rostrum in apical half dorsally swollen, basal half dorsally broad flattish depressed.

c^1. Scape not reaching to hind margin of eye, elytra ovate.

d^1. Antennal scrobe distinctly defined, groovelike, curved backward and downward. Episternal suture of metathorax grooved the whole length..... **Pachyrrhynchus** Germar.

d^2. Antennal scrobe posteriorly enlarged to a triangular depression, the upper margin of which is directed toward middle of eye, the lower margin toward ventral side of rostrum. Episternal suture of metathorax only anteriorly depressed. **Sphenomorpha** Behrens.

c^2. Antennal scape reaching to hind margin of eye, elytra in both sexes somewhat depressed..... **Eupachyrrhynchus** Heller.

b^2. Rostrum in apical half not swollen, without a large dorsal depression, mostly with a medial longitudinal groove.

e^1. Eyes almost hemispherically produced.

f^1. Scape not reaching to hind margin of eye, rostrum slightly longer than broad..... **Pantorhytes** Faust.

f^2. Scape reaching beyond hind margin of eye, prosternum slightly emarginate, elytra spherically inflated, basal margin not ridged. **Apocyrtus** Erichson.

e^2. Eyes slightly bulging, prothorax subcylindrical, elytra dorsally flattened, laterally strongly and abruptly declined in an acute angle..... **Proapocyrtus Schultze.**

g^1. Upper margin of scrobe ridged, rostrum regularly arched crosswise as well as lengthwise, tapering toward apex. **Pseudapocyrtus** Heller.

g^2. Upper margin of scrobe not ridged.

h^1. Hind femora not armed, or only with a short obtuse tubercle near base.

[36] Ent. Mitteil. 1 (1912) 309; Nova Guinea, Zool. 9 (1914) 647; Philip. Journ. Sci. § D 10 (1915) 219; Deutsche Ent. Zeitschr. (1916) 281–289; Philip. Journ. Sci. 19 (1921) 542–548; Tijdschr. v. Ent. (1923) 47; Stett. Ent. Zeitg. (1923) 8.

[37] Philip. Journ. Sci. § D 7 (1912) 250–258; 13 (1918) 276; 371–378; 15 (1919) 549–557; 20 (1920) 199; Deutsche Ent. Zeitschr. (1922) 36–45; Philip. Journ. Sci. 21 (1922) 574–587; 23 (1923) 77–83; antea 599–604.

i^2. Rostrum dorsally flat, only with a more or less strongly indicated medial longitudinal groove. Inner edge of hind tibiæ with a number of obtuse toothlike projections; first and second abdominal sternites connate.

j^1. Prothorax with dimplelike depressions dorsolaterally, elytra at apex forming a mammillary projection; hind femora, in both sexes, not nearly reaching to apex of elytra..... Eumacrocyrtus Schultze.

j^2. Prothorax without dimplelike depressions, elytra not forming a mammillary projection apically.

Macrocyrtus Heller.

i^2. Rostrum with a broad longitudinal depression, hind femora reaching distinctly beyond apex of elytra, hind tibiæ at most with some fine thorns..... Nothapocyrtus Heller.

h^2. Hind femora beset with a sharp thorn on underside before apex, fore coxæ touching each other.[38]

a^2. Rostrum with distinct basal cross groove.

k^1. Rostrum in apical part transversely humplike swollen, eyes prominently bulging, at upper margin with a groove, scape short, not nearly reaching hind margin of eye..... Apocyrtidius Heller.

k^2. Rostrum in apical part not swollen, eyes not prominently bulging, scape at least reaching to hind margin of eye.

Metapocyrtus Heller.

l^1. Rostrum as long as broad, squarish or trapezoidal, the lateral margins set off at right angles, dorsally lengthwise arched and separated by a prominent cross groove from curved front.

Subg. Artapocyrtus Heller.

l^2. Rostrum longer than broad.

m^1. Dorsolateral edge of rostrum acute, at base falling off at right angles.

n^1. Rostrum dorsally curved lengthwise, moderately densely punctured, without any trace of longitudinal ridges, the anterior margin of prothorax raised and becoming broader lateroventrally.

o^1. Prothorax punctured, with distinct anterior submarginal groove, prosternum slightly emarginate.

Subg. Sphenomorphoidea Heller.

o^2. Prothorax granulate, anterior submarginal groove dorsally entirely obliterated, the anterior margin laterally becoming broader and ventrally distinctly emarginate.

Subg. Sclerocyrtus Heller.

[38] The species resembling *Apocyrtus* which by their characters may lead to this place in the key, must, on account of the visible mandibular scar, be placed among the Scythropines; they belong to the genus *Isoptera* Faust, Ent. Zeitg. Stett. (1895) 56, 4.—Translation of Heller's footnote in Philip. Journ. Sci. § D 7 (1912) 302.

n^2. Rostrum dorsally straight, prothorax mostly not granulate, the anterior margin either all around uniformly narrow or growing still narrower or broader toward underside.
Subg. **Orthocyrtus** Heller.

m^2. Dorsolateral edge of rostrum entirely rounded.

p^1. Elytra elliptical or ovate, as a rule with a ridged basal margin, rarely dorsally flattened; if so, then with a ridged basal margin.

q^1. Elytra more or less striate-punctate, never granulate.
Subg. **Metapocyrtus** Heller.

q^2. Elytra more or less densely granulate.
Subg. **Trachycyrtus** Heller.

p^2. Elytra in the male dorsally flattened, the greatest width behind the middle, posterior declivity very abrupt; in the female the latter is more or less oblique; in both sexes mostly a tuft of setæ at sutural beginning of posterior declivity.
Homalocyrtus Heller.

Genus PACHYRRHYNCHUS Germar

Pachyrrhynchus GERMAR, Ins. Spec. Nov. (1824) 336.

Type species, *P. moniliferus* Germar from Luzon, Philippine Islands.

Head convex, eyes lateral, moderately bulging. Rostrum short and stout, at most slightly longer than broad, dorsally with an indistinct basal transverse furrow, but mostly without the latter. Basal half with a broad, more or less strongly pronounced squarish or oblong depression. Apical half dorsally more or less transversely swollen. Sides angulate, with the dorsolateral edges more or less pronounced. Antennal scrobes deep, groovelike, sharply defined, curved downward toward underside. Antenna short and robust, scape not reaching to hind edge of eye, funicular joints together with club one-fourth to one-third longer than scape. Prothorax slightly variable in length, more or less ovoid-ellipsoid or subspherical, truncate at base and anteriorly. Episternal suture of metasternum grooved the whole length. Elytra short to oblong-ovate.

Range: Riu Kiu Islands, Philippines, and Moluccas.

Heller, in order to facilitate determination of the species of *Pachyrrhynchus*, arranged the species mainly according to their color designs or scale markings, into seven groups. Such an arrangement is in the majority of instances quite satisfactory, but in a number of instances gives a wrong conception, in as much as morphologic-heterogenous species are placed together in the same group. For example in Group I are located *Pachy-*

rrhynchus ochroplagiatus Heller, *P. eques* Heller, *P. morotaiensis* Vollh., *P. forsteni* Vollh., and *P. infernalis* Fairm.

The first two and the last one of the above species are certainly very far apart from each other as well as from the other two species, *P. morotaiensis* and *P. forsteni;* the last two are the only species of Group I which are closely related to each other or homogeneous in their characters. Another example of a heterogeneous conglomeration is found in Group III. In this group the homogeneous species *P. pinorum* Pascoe, *P. tristis* Heller, and *P. lacunosus* Heller are placed together with the rather heterogeneous species *P. perpulcher* Waterh., *P. erichsoni* Waterh., *P. schoenherri* Waterh., *P. venustus* Waterh., and *P. smaragdinus* Behrens.

I am well aware of the difficulties involved in constructing a satisfactory arrangement of the species of *Pachyrrhynchus,* on account of the great diversity of superficially apparently heterogeneous forms; but I deem it preferable to arrange the species in groups according to their morphologic affinities and along lines of natural relations, such groups to be designated in accordance with a typical form of species with which all the other species in a given group are more or less homogeneous.

At the present time it seems premature to assign the different species of *Pachyrrhynchus* to subgenera, since in a number of instances subgeneric divisions would have to be created for certain single species. In as much as many localities are represented by a few specimens of a single species, and as many regions are entirely unrepresented in the collections, it seems advisable to make no subdivision until additional material is obtained rather than to make a large number of subgenera of which many would contain but one species each. Owing to the presence of intergrading characters it does not seem advisable to found subgenera upon single species, since more material would probably relegate some of the subgenera to the scrap heap of discarded synonymy.

GROUP I

The members of this group are typified by the species *Pachyrrhynchus moniliferus* Germ. Small to medium-sized species and rather stout in build. Eyes not especially bulging. Prothorax mostly as long as broad, subglobular, the sides evenly rounded with the greatest width at the middle. Elytra short ovate. General color black, with two exceptions, *P. sphaericollaris* Schultze and *P. rugicollis* Waterh. The following species

are placed in this group: *Pachyrrhynchus orbifer* Waterh., *P. infernalis* Fairm., *P. zebra* Schultze, *P. stellio* Heller, *P. rugicollis* Waterh., *P. sphaericollis* Schultze, *P. jugifer* Waterh., *P. decussatus* Waterh., *P. phaleratus* Waterh., *P. halconensis* Schultze, *P. reticulatus* Waterh., *P. circulatus* Heller. The last two are intermediate species, leading to Group II.

Key to species of Pachyrrhynchus, Group I.

a^1. General color not black.
  b^1. Dark purplish coppery, with metallic luster, no scale markings. **P. sphaericollaris** Schultze.
  b^2. Dark reddish brown, prothorax and elytra with rugosities filled with reddish golden scales..... **P. rugicollis** Waterh.
a^2. General color black.
  c^1. Color uniform; no scale markings present.
    d^1. Elytra rather strongly coriaceous, dull, coarsely punctate-striate. **P. moniliferus var. inornatus** Waterh.
    d^2. Elytra finely coriaceous, moderately glossy, finely punctate-striate. **P. infernalis** Fairm.
  c^2. Not uniform; with various scale markings.
    e^1. Elytra with separate or confluent, narrow or broad, entire, circular or reticulated markings.
      f^1. Elytra with separated pale yellow rings. **P. circulatus** Heller.
      f^2. Elytra with confluent, narrow or broad, pale green or yellowish green, rounded or netlike markings.
        g^1. Line markings broad; prothorax with a diamond-shaped inclosed area on disk; elytra with reticulated lines. **P. reticulatus** Waterh.
        g^2. Line markings narrow; prothorax discally with a cross figure; elytra with netlike markings. **P. reticulatus cruciatus** Schultze.
    e^2. Elytra with various markings, in but one instance forming narrow interrupted circular markings.
      h^1. Prothorax and elytra with roundish or elongate rose-colored or golden spots.
        i^1. Elytra with a large sutural spot; all spots rose colored..... **P. roseomaculatus** Waterh.
        i^2. Elytra without a sutural spot; all spots golden. **P. striatus** Waterh.
      h^2. Prothorax and elytra with longitudinal or transverse lines or bands entire or interrupted.
        j^1. Prothorax with both median and dorsolateral longitudinal lines.
          k^1. All lines on elytra very narrow, present in fragmentary traces, transverse line much interrupted, consisting of a row of dots. **P. stellio** Heller.

k^2. Lines on elytra broader, transverse bands not interrupted; size large for the group.

l^1. Elytra with a broad irregular transverse band and broad and abbreviated irregular longitudinal stripes..... **P. halconensis Schultze.**

l^2. All lines on elytra much narrower than in *halconensis.*

m^1. Elytra with the dorsolateral longitudinal lines interrupted in the middle but continuous on apical half.

P. decussatus Waterh.

m^2. Dorsolateral lines on basal half of elytra discontinuous with that of apical half.

P. phaleratus Waterh.

j^2. Prothorax with either a longitudinal medial line or dorsolateral longitudinal lines.

n^1. Prothorax only with dorsolateral longitudinal lines, and a band at anterior and posterior margins... **P. libucanus sp. nov.**

n^2. Prothorax without dorsolateral lines, but a medial line or marking connected with a transverse line or marking before the middle.

o^1. Basal half of elytra covered with pink scales except for one large bare circular sutural spot.... **P. jugifer Waterh.**

o^2. Basal half of elytra variously marked, but never with a single circular sutural spot.

p^1. Basal half of elytra with from three bare circular areas to one continuous transverse area, scaled areas bluish green, pinkish, and various other colors, not brilliant.

P. orbifer Waterh.

q^1. All lines and bands of elytra broken up into fine pale yellow interrupted lines inclosing circular spots.

P. orbifer var. circulifer Waterh.

q^2. Elytra with more or less well defined spotlike bare areas; scaled areas brilliant greenish golden or coppery. **P. orbifer gemmans Waterh.**

q^3. Elytra with transverse bare areas confluent along suture, scaled areas brilliant reddish. **P. orbifer gemmans var. ardens Chevr.**

q^4 Each elytron with three large well-defined transverse dark blue spots.

P. orbifer azureus Schultze.

p^2. Basal half of elytra with two prominent dorsolateral longitudinal lines.

r^1. Longitudinal dorsolateral lines very narrow, not interrupted in the middle; medial transverse line more or less fragmentary.

P. zebra Schultze.

r^2. Longitudinal dorsolateral lines interrupted medially or for the greater part of their length; a sharply defined entire or interrupted medial transverse band present.

s^1. Elytra with the longitudinal dorsolateral lines very narrow, more or less interrupted in the middle; medial transverse band narrow, regularly interrupted.

P. moniliferus Germar.

s^2. Larger. Lines on elytra broader, medial transverse line not interrupted. P. moniliferus chevrolati Eyd. and Soul.

s^3. Elytra, medial transverse band very broad or interrupted, forming irregular spots.

P. moniliferus stellulifer Heller.

Pachyrrhynchus orbifer Waterh. Plate 1, fig. 3 (lateral view); Plate 6, figs. 1 to 11.

Pachyrrhynchus orbifer WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 220; Trans. Ent. Soc. London I 3 (1843) 323;[89] SCHOENH., Gen. Curc. Suppl. 8 (1845) 386; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Pachyrrhynchus fimbriatus CHEVR., Rev. Zool. (1841) 224; SCHOENH., Gen. Curc. Suppl. 8 (1845) 387.

Pachyrrhynchus globulipennis CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389.

Pachyrrhynchus pretiosus CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 388.

Pachyrrhynchus scintillans CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389.

[89] Pachyrrhynchus orbifer Waterh.

Niger; thorace in medio fascia transversa, et pone hanc plaga longitudinali a transversa usque ad marginem posticum thoracis excurrente, his e squamis caeruleo-viridibus effectis; elytris squamis caeruleo-viridibus indutis, areis 7-rotundatis denudatis.

Long. corp. 6 lin., lat. 3 lin.

Pachyrrhynchus alboguttatus CHEVR., Rev. Zool. (1841) 226; ERICHS., Wiegm. Arch. 2 (1842) 242; SCHOENH., Gen. Curc. Suppl. 8 (1845) 392.

Pachyrrhynchus fahrei SCHOENH., Gen. Curc. Suppl. 8 (1845) 388.

Pachyrrhynchus inornatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 326; HELLER, Philip. Journ. Sci. § D 7 (1912) 303.

Pachyrrhynchus ardens CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389; L. VON HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 3; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Pachyrrhynchus circulifer CHEVR., Rev. Zool. (1841) 226; SCHOENH., Gen. Curc. Suppl. 8 (1845) 392.

Pachyrrhynchus gemmans CHEVR., Rev. Zool. (1841) 225; ERICHS., Wiegm. Arch. 2 (1844) 285; SCHOENH., Gen. Curc. Suppl. 8 (1845) 388; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Var. β SCHOENH., loc. cit.

Var. γ SCHOENH., loc. cit.

Var. δ SCHOENH., loc. cit.

Pachyrrhynchus orbifer subsp. *azureus* SCHULTZE, Philip. Journ. Sci. 21 (1922) 577, pl. 2, fig. 8.

Black; head and prothorax shiny, elytra dull, very finely coriaceous. Very nearly related to *P. moniliferus* Germ. Rostrum in apical half scatteredly punctate, basal half with a rather strongly pronounced dorsal depression and a rather indistinct longitudinal groove in the middle. Front with a somewhat squarish bluish green scale spot, another oblong spot below each eye. Prothorax hardly broader than long, subglobular, very finely scatteredly punctate. In the middle an irregularly broader or narrower scaly crossband which is confluent with a scaly area at each side. From the discal part extending to hind margin a wedge-shaped scale spot. The scaleless parts on prothorax form three smaller or larger areas, one in the anterior and two in the posterior half. Elytra punctate-striate, the punctures more or less strongly pronounced. Elytra beset with bluish green scales with the exception of a cross row of three bare areas at base, the larger one of which is divided by suture; another cross row of three bare areas in apical half of elytra and a small bare roundish area at apex.

These bare or scaleless areas are very variable in size and shape, and may be confluent laterally or longitudinally. In most specimens the bare areas are surrounded by pale greenish scale lines (Plate 6, figs. 2, 3, 4, 7, 8) which coloration contrasts with the other scale coloration of the elytra. Femora with an

oblong scale spot in the middle and another spot near apex. Penis structure, Plate 3, fig. 29.

Male, length, 8.5 to 12.5 millimeters (without rostrum); width, 3.5 to 5.5. Female, length, 8.8 to 12.5 millimeters (without rostrum); width, 4.2 to 6.5.

LUZON, Benguet Subprovince, Bued River Valley; Baguio; Mount Santo Tomas; Mount Mirador; Trinidad; Mountain Trail, Baguio to Bontoc: Kalinga Subprovince, Lubuagan: Ilocos Norte Province, Bangui, Burgos, Mount Nagapatan: Cagayan Province, Sanchez Mira (*Schultze*). Abundant on *Jatropha curcas* Linn.

This species has a relatively wide distribution but only in the mountainous parts of northern Luzon. Very probably some local forms will be found in the small islands north of Luzon. I know of no other species of *Pachyrrhynchus* which exhibits such a great variety of forms as *P. orbifer* in reference to the scale designs or markings and the coloration of same. Waterhouse [40] recognized the very great variability of this species and its close relation to *P. moniliferus* Germ. In this connection attention is called to the following well-founded remarks [41] by this author concerning *P. orbifer:*

> This species I suspect, as well as that described under the name *P. chlorolineatus*, is but a local variety of *P. moniliferus*.

Pachyrrhynchus orbifer Waterh. replaces *P. moniliferus* Germ. in the northern half of Luzon in the mountainous regions. The specific demarcation characters between the two species, as such, are in some forms extremely inconspicuous and slight. But for the sake of easier determination and better recognition of the many local forms and variations of both species it is strongly advisable to retain for *P. orbifer* the specific status. My conclusions in this respect I base on the examination of several thousand specimens of both of these species.

In several instances a certain variation is found only in a relatively small locality, but in other instances a rather large series of intermediate forms among the more strongly pronounced variations were found together in some other localities. It is very easy to select hundreds of variations from a large amount of material of *P. orbifer*, many of which, if seen in single specimens, will convey strongly the idea that they rep-

[40] Trans. Ent. Soc. London I 3 (1843) 324–327.
[41] Ann. & Mag. Nat. Hist. 8 (1841) 220.

resent different species. Both Waterhouse and Chevrolat were misled in this way. Unfortunately, as Behrens [42] rightly says, Chevrolat described part of the material pertaining to this group collected by Cuming at about the same time that Waterhouse did. Several of the species indicated above must be placed as synonyms. In order to recognize some of the more characteristic forms of *P. orbifer* it seems advisable to retain some of the older names for certain varieties as follows:

Pachyrrhynchus orbifer var. **inornatus** Waterh. Plate 6, fig. 1, ♂.

Uniformly black; elytra dull black, rather strongly coriaceous and regularly punctate-striate.

LUZON, Ilocos Norte Province, Bangui (*Schultze*). CALAYAN, Babuyanes group (*McGregor*).

Pachyrrhynchus orbifer var. **circulifer** Chevr. Plate 6, fig. 2, ♀.

Black; prothorax and elytra with markings consisting of fine pale green or pink interrupted scale lines. The lines on prothorax form a figure like the letter **T**. On the elytra in basal half the scale lines circumscribe three semicircular areas which are placed in a cross row. Behind the middle another cross row of three areas and a small area at apex. Femora with a scale spot in the middle and another near apex.

LUZON, Ilocos Norte Province, Bangui (*Schultze*).

This variety was described by Chevrolat as *P. circulifer;* Waterhouse also mentioned this form specially, and in some instances he assumed that the specimens were old and rubbed off and resembled *P. reticulatus* Waterh. subsp. *cruciatus* Schultze (Plate 5, fig. 3). I examined a large number of perfectly fresh specimens which also give the appearance of being rubbed off. Such specimens have the above indicated fine scale lines and the whole surface is beset with scattered rudimentary scales, except on the bare semicircular areas (Plate 6, fig. 3, female). In certain specimens this kind of rudimentary scale formation is very faintly indicated, in others it is more pronounced and to such a degree that the bare areas are plainly set off. Such specimens represent intermediate varieties leading up to specimens which have the scale formation fully developed, but in which the variations in coloration again are manifold (Plate 6, figs. 4, 6, 7, 8).

I received numerous examples of these varieties from Bangui, Burgos, and Mount Nagapatan, Ilocos Norte Province, Luzon.

[42] Stett. Ent. Zeitg. 48 (1887) 216.

The general scale coloration in these specimens is either pale or dark violet, pale green or bluish green, or pale reddish brown. In the neighborhood of Baguio, Benguet Subprovince, I collected many specimens which have pale green or light blue scale coloration; also some examples in which the general markings are present in only a fragmentary way, being in some instances reduced to more or less interrupted bands, lines, or spots (Plate 6, figs. 10, 11). Some of the last-mentioned varieties bear a strong resemblance to *P. moniliferus* Germ.

Another rather strongly fixed local race I designate as—

Pachyrrhynchus orbifer subsp. gemmans Chevr. Plate 6, fig. 9, ♂.

Black, shiny, the scale markings brilliant golden, coppery red or green, glittering like precious stones. Prothorax with a broad crossband which widens at the sides. Elytra regularly and strongly punctate-striate. The bare areas more or less confluent with each other, forming a crossband, sometimes confluent along suture. Femora with the usual spot at middle and near apex.

Male, length, 10.5 to 13 millimeters (without rostrum); width, 4.5 to 6. Female, length, 11 to 13 millimeters (without rostrum); width, 5 to 6.5.

LUZON, Cagayan Province, Tuao, Rio Chico (*Baker*).

Another rather striking form of *P. orbifer* subsp. *gemmans* Waterh. is—

Pachyrrhynchus orbifer subsp. gemmans var. ardens Chevr. Plate 6, fig. 5, ♂.

Black, the scale markings of a brilliant pale flesh-colored hue.

LUZON, Cagayan Province, Sanchez Mira (*Schultze*).

Still another rather isolated form is—

Pachyrrhynchus orbifer subsp. azureus Schultze. Plate 1, fig. 2 (lateral view); Plate 5, fig. 11.

Black; prothorax and elytra with lapiz lazuli crossbands. Front with an oblong scale spot. Prothorax with a crossband which becomes very broad at sides. A wedge-shaped scale spot extends from discal area to hind margin. Elytra indistinctly punctate-striate. Each elytron with a large crossbandlike scale spot at base, not quite reaching suture, another in the middle, and another in apical third. The last-mentioned spot is connected along margin with the spot in the middle.

Male, length, 12 millimeters (without rostrum); width, 5.6.

LUZON, Benguet Subprovince, Kabayan (*Schultze*).

Pachyrrhynchus infernalis Fairm. Plate 1, fig. 1 (lateral view); Plate 8, fig. 6.

Pachyrrhynchus infernalis Fairm., Bull. Soc. Ent. France (1897) 70; Heller, Philip. Journ. Sci § D 7 (1912) 304.

Black; head, prothorax, and legs glossy, elytra rather dull. Very nearly related to *P. orbifer* Waterh. Rostrum in apical half scatteredly punctured. Basal half with a strongly developed depression, the dorsolateral edges of which are swollen. Dorsal depression separated from front by an indistinct cross groove. Prothorax subglobular, slightly broader than long, very fine and regularly scatteredly punctured. Dorsally near posterior margin an indistinct rudimentary longitudinal depression. Elytra short and stout ovate, very finely coriaceous and striate-punctate. The punctures finer and closer than in *P. orbifer* Waterh. Underside and legs uniformly black.

Male, length, 11.5 millimeters (without rostrum); width, 5.8.

Liu Chiu Islands, Yayoyama, Ishigaki-shima.

This species is, as stated above, very closely related to *P. orbifer* Waterh., particularly to the uniformly black form var. *inornatus* Waterh., from northern Luzon and the Babuyan group, which it absolutely resembles superficially. Unfortunately, I have only one specimen of *P. infernalis* before me which precludes definite decision as to whether the slight structural differences between it and *P. orbifer* are constant or not. Another noteworthy fact concerning this species is that it is the most northern representative of all the Pachyrrhynchides. Its peculiar geographic distribution seems to indicate that land connections between the Liu Chiu Islands and the Philippines probably existed in ages past.

Pachyrrhynchus moniliferus Germ. Plate 1, fig. 4, ♀ (lateral view); Plate 5, fig. 12.

Pachyrrhynchus moniliferus Germ., Ins. Spec. Nov. 1 (1824) 336; No. 476, pl. 1, fig. 12, *a*, *b*; Schoenh.,[43] Gen. Curc. 1 (1833) 513; Dej., Cat. Col. ed. 2, 247; ed. 3 (1837) 270; Schoenh., Gen. Curc. 5 (1839) 823; op. cit. 8 (1845) 386; Waterh., Proc. Ent. Soc. London (1841) 20; Ann. Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 323.

[43] P. moniliferus.

Ater, subtus viridi maculatus, thoracis cruce, elytrorum linea transversa, maculari, media, linea angulata baseas arcuque apicis viridi-adamantinis.

Pachyrrhynchus monilifer GERM., Gemm. and Harold, Cat. Col. (1871) VIII, 2244; BEHRENS, Stett. Ent. Zeitg. 48 (1887) 212; HELLER, Philip. Journ. Sci. § D 7 (1912) 310; SCHULTZE, Cat. Philip. Col. (1915) 132.

Pachyrrhynchus confinis CHEVR., Rev. Zool. (1841) 226.

Black; prothorax and elytra with fine, mostly interrupted, pale green scale lines. Rostrum in apical half densely punctured, in basal half a shallow, somewhat triangular depression with a faintly indicated longitudinal groove. Front scatteredly punctate, with a small oblong scale spot. Sides of rostrum and head below eye with a patch of small whitish setæ and some scattered scales. Prothorax as long as broad, the greatest width before the middle, finely punctate and glossy. In the middle a mostly interrupted longitudinal line and an interrupted cross line across discal area. Another fine line at lateral margins which is continued more or less fragmentarily along anterior and posterior margins. The lines on prothorax above form a figure like a ✢ or the letter ┳. Elytra short, stout ovate, black, dull, very finely coriaceous and with rather faint rows of punctures, the latter more pronounced in the male. At base a fine line, which is interrupted at suture, and continued more or less interrupted as submarginal line to near apex, at which place it is joined by a short longitudinal line. A fragmentary short branch of this same longitudinal line is present at base. Across the middle of elytra a fine interrupted cross line confluent with submarginal line. Femora with a dash in the middle and a patch of scales near apex. Plate 3, fig. 28, penis structure.

Male, length, 8 to 12 millimeters (without rostrum); width, 3.5 to 5.5. Female, length, 9 to 12.5 millimeters (without rostrum); width, 4.5 to 6.

LUZON, Rizal Province, Montalban, Taytay, Antipolo, Bosoboso: Laguna Province, Los Baños, Mount Maquiling, Paete: Bataan Province, Limay (*Schultze*).

This species is the type of the genus *Pachyrrhynchus*. The typical specimens of this species were collected by Eschscholtz in the neighborhood of Manila during December, 1817, probably on his trip to Taal Volcano. *Pachyrrhynchus moniliferus* is variable in size, as well as in the line markings and coloration of the latter. The lines on prothorax and elytra may be present as a few dots, or as interrupted or complete lines. The typical form of *P. moniliferus* represents the least strongly

pronounced form in a series of local forms or races, most of which are connected up through intermediate forms.

The general distribution of this species and its local races is mainly between 13° and 15° north latitude, in central and southern Luzon, Polillo, Mindoro, and Catanduanes and reaches in a southeasterly direction to Samar.

Pachyrrhynchus moniliferus subsp. chevrolati Eyd. and Soul. Plate 1, fig. 5 (lateral view); Plate 5, fig. 20.

Pachyrrhynchus chevrolati Eyd. and Soul., Rev. Zool. (1839) 266; Desm., Voy. La Bonite 1 (1841) 313, pl. 3, figs. 25–26; Heller, Philip. Journ. Sci. § D 7 (1912) 309.

Pachyrrhynchus concinnus Waterh., Proc. Ent. Soc. London (1841) 45; Trans. Ent. Soc. London I 3 (1843) 322; Heller, Abh. Ber. Königl. Zool. Anthr.-Ethnogr. Mus. Dresden 7 (1898–99) 6; Philip. Journ. Sci. § D 7 (1912) 321.

Pachyrrhynchus chlorolineatus Waterh., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. I 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 323, 325; Heller, Philip. Journ. Sci. § D 7 (1912) 309.

Var. *jagori* Heller, Philip. Journ. Sci. § D 7 (1912) 321.

Pachyrrhynchus mandarinus Chevr., Rev. Zool. (1841) 226; Heller, op. cit. 310.

Larger than typical *P. moniliferus* Germ., prothorax laterally more rounded, elytra more oblong-ovate. The lines on prothorax and elytra not interrupted and much broader, forming stripes. The coloration of the markings yellowish or greenish golden. Rostrum with an oblong scale spot which reaches above front. Prothorax, the longitudinal line is more wedge-shaped and reaches only to the cross line in the middle. The dorsal longitudinal stripes on elytra in basal half are confluent with the crossband, those in apical half not quite reaching the latter.

Male, length, 11 to 13.5 millimeters (without rostrum); width, 4.8 to 6. Female, length, 13 to 14 millimeters (without rostrum); width, 6 to 6.5.

Luzon, Tayabas Province; Albay Province. Polillo. Catanduanes, Virac. Samar, Catarman, Borongan (*Schultze*).

In *P. concinnus* Waterh. the rows of punctures on the elytra are more distinct, the longitudinal stripes are broader and somewhat divergent at base. The coloration of the markings is very pale green.

Samar, Borongan.

Var. *jagori* Heller has the longitudinal marking on the prothorax strongly pronounced wedge-shaped. On the elytra in the apical half are two small oblong spots.

Pachyrrhynchus moniliferus subsp. **stellulifer** Heller. Plate 5, figs. 14 and 18.

Pachyrrhynchus monilifer var. *stellulifer* HELLER, Philip. Journ. Sci. § D 7 (1912) 322.

Black; head, prothorax, and legs glossy bluish black. Scale markings creamy white, flesh color, or pale greenish. Apical half of rostrum strongly punctate, the depression in basal half more pronounced. Front with a small scale spot. Prothorax more rounded at sides. The scale markings on prothorax and elytra much broader, the crossband on the latter sometimes very broad, or also interrupted, forming a cross row of spots.

Male, length, 12 to 12.5 millimeters (without rostrum); width, 5.5 to 6.2. Female, length, 12 to 12.8 millimeters (without rostrum); width, 5.8 to 6.

MINDORO, Naujan (*Taylor*); Mangaran (*C. M. Weber*); San Jose; Mount Halcon (*Schultze*).

This subspecies represents also a rather well-defined local race of *P. moniliferus*.

Pachyrrhynchus zebra Schultze. Plate 1, fig. 6, ♀ (lateral view); Plate 5, fig. 2, ♀.

Pachyrrhynchus zebra SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 253, pl. 1, fig. 5.

Black, with longitudinal, light bluish or greenish scale stripes. Rostrum with a deep pitlike depression in the middle, which disappears between the eyes. Front with a fine medial groove and an elongated spot not continued on vertex. Prothorax smooth and shiny. A narrow band on fore margin continued laterally to hind margin. A transverse medial band joins the side marginal stripe. From disk of thorax, arising from transverse band, a longitudinal stripe to posterior margin, forming the letter T. Elytra very finely wrinkled like leather with very pronounced longitudinal puncture rows. Each elytron with four longitudinal stripes, which run together at basal margin and in apical triangle. A narrow subsutural stripe in apical half of each elytron not quite reaching apex. The broadest stripes are the one located between the second and third rows of punctures and the lateral marginal stripe, both of which are also broader toward base and toward apical triangle. Underside with a spot on mesosternum and metasternum. First abdominal segment with a large spot on each side. Each femur with a scale spot in the middle and a ringlike spot near apex.

Female, length, 11.5 millimeters (without rostrum); width, 5.5.

LUZON, Benguet Subprovince, Mount Santo Tomas (*Schultze*).

Pachyrrhynchus libucanus sp. nov. Plate 3, fig. 12 (lateral view); Plate 9, fig. 5, ♂.

Black; head, prothorax, and legs glossy, elytra rather dull. Prothorax and elytra with pale greenish golden bands and stripes. Rostrum, basal half dorsally strongly but flattish depressed with a large bifid scale spot and a medial groove, the latter reaching to front. Prothorax with a scale band at anterior and posterior margins, both of which are connected by a lateral marginal longitudinal stripe. Toward each side, dorsolaterally, a longitudinal stripe reaching from base to near anterior margin. Elytra finely coriaceous, coarsely and regularly punctate-striate; in the third interstice a medially interrupted stripe, confluent at base with a lateral marginal stripe, the latter continued to apex and confluent again with the abbreviated stripe of the third interstice. A rather broad transverse band in the middle confluent with the marginal stripes. In apical half in the fifth interstice a small roundish spot and in the seventh interstice an elongate spot. Femora with a small spot near apex.

Male, length, 13 millimeters (without rostrum); width, 6.6.

LIBUCAN ISLAND near Samar (*A. Celestino*).

This species resembles superficially certain forms of *P. moniliferus chevrolati*, but is readily distinguishable from the latter by the peculiarly shaped rostrum and distinctly different markings on prothorax.

Pachyrrhynchus phaleratus Waterh. Plate 2, fig. 30 (lateral view); Plate 5, fig. 19, ♀.

Pachyrrhynchus phaleratus WATERH., Proc. Ent. Soc. London (1841) 19, Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 320; SCHOENH., Gen. Curc. Suppl. 8 (1845) 385; HELLER, Philip. Journ. Sci. § D 7 (1912) 309.

Black with greenish yellow scale stripes. Rostrum dorsally in the middle with broad strongly pronounced transverse groove and another indistinct groove at base, each groove beset with two small scale spots. Both transversal grooves are connected by a narrow and sharply defined longitudinal medial groove. Sides of rostrum and head with a scale spot. Prothorax as long as broad, dorsally before the middle with a transverse line which branches dorsolaterally, one branch extending to the an-

terior, the other to the posterior margin, being continued as lateral marginal stripes and circumscribing the sides. Another short longitudinal line dorsally in the middle reaching from the transverse line to an interrupted posterior marginal line. Elytra short and broad ovate, dull black, very finely coriaceous. A narrow stripe at base is continued as marginal stripe to apex; in the middle a transverse line confluent with marginal stripe. Each elytron in basal half dorsolaterally with a short longitudinal stripe reaching from base to near the transverse line, rarely joining the latter. Apical half with a sutural stripe confluent with marginal stripe at apex, and a longitudinal stripe, which is located more laterally than the one in basal half, from the transverse line to marginal stripe. Shortly before the junction this longitudinal stripe sends off a short branch. Prosternum with an anterior and a posterior marginal line, mesosternum with a transverse scale band, metasternum and first abdominal sternite with a spot laterally. Femora with a circular scale band near apex. Penis structure, Plate 3, fig. 24.

Male, length, 12.7 millimeters (without rostrum); width, 5.8. Female, length, 15.5 millimeters (without rostrum); width, 8.

CATANDUANES, Virac (*Schultze*).

In the basal half of each elytron, in the male, sometimes a rudimentary second longitudinal stripe is present, being in line with the stripe of the apical half. This species is readily distinguished from related species by the peculiar sculpture of the rostrum.

Pachyrrhynchus decussatus Waterh. Plate 1, fig. 25 (lateral view); Plate 4, fig. 3.

Pachyrrhynchus decussatus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 321; SCHOENH., Gen. Curc. Suppl. 8 (1845) 385; HELLER, Philip. Journ. Sci. § D 7 (1912) 309, pl. 1, fig. 14.

Black, with greenish yellow scale stripes. Rostrum dorsally in the middle with a strongly pronounced cross groove beset with scales; from the cross groove extending to the front a longitudinal depression beset with an elongate scale spot. Sides of rostrum and head also with a scale spot. Prothorax as long as broad with a more or less interrupted transverse scale stripe before the middle confluent with a longitudinal stripe at the lateral margins. Three other longitudinal stripes, one dorsally in the middle and one toward each side, dorsolaterally, extend from the transverse stripe to base. Another scale stripe, dor-

sally interrupted, at anterior margin. Elytra short ovate, finely coriaceous and very indistinctly striate-punctate. A transverse stripe at base continued as marginal stripe to apex. In the middle an irregular crossband confluent with the marginal stripes. Dorsolaterally a longitudinal stripe, interrupted behind the crossband, extending from base to near apex, where it becomes confluent with the marginal stripe. In the basal half laterally another longitudinal stripe reaching only to the transverse stripe, the latter at the junction mostly spotlike expanded. The dorsolateral stripe in apical fourth with a short, forward-curved branch. Prosternum and mesosternum closely beset with scales, metasternum and first abdominal sternite with a large scale spot laterally. Femora with a broad circular scale band near apex, anterior femora in addition with an oblong scale patch above. Penis structure, Plate 3, fig. 23.

Male, length, 14 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 6.5.

CATANDUANES, Virac (*Schultze*).

This species is closely related to *P. phaleratus* Waterh. The scale markings are somewhat variable. One specimen which I received from Dr. Dexter Allen, from the above locality, has a fine interrupted sutural scale line in apical half; in another specimen a small oblong submarginal spot is located in apical third.

Pachyrrhynchus stellio Heller. Plate 1, fig. 24 (lateral view); Plate 5, fig. 15, ♀.

Pachyrrhynchus stellio HELLER, Philip. Journ. Sci. § D 7 (1912) 320.

Black; prothorax and elytra with pale green scale lines. Related to *P. moniliferus* Germ., but larger and slenderer in form. Rostrum and lines on prothorax very similar to those of *P. phaleratus* Waterh. Rostrum with a rather shallow and flat depression in basal half and a broad transverse scale spot in the middle. Another spot below eye. Prothorax longer than broad, bluish black, glossy, very finely punctate. In basal half of prothorax a combination of lines forming the figure T; the cross line of the latter branches laterally, forward and backward, and circumscribes each side. Elytra finely coriaceous and without any puncture rows. The line markings almost identical with those in *P. moniliferus* Germ., an interrupted cross line in the middle, furthermore each elytron with a short fragmentary longitudinal line at base and apex and a marginal line in apical half.

Male, length, 14 millimeters (without rostrum); width, 6. Female, length, 13.5 millimeters (without rostrum); width, 6.5.

LUZON, Bataan Province, Lamao, Mount Mariveles (*Schultze*).

Pachyrrhynchus striatus Waterh.

Pachyrrhynchus striatus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 317; SCHOENH., Gen. Curc. Suppl. 8 (1845) 384; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Black; prothorax and elytra with golden scale spots. Very closely related to *P. roseomaculatus* Waterh. in general body form as well as in the position of the spots. Front with a scale spot, prothorax with a scale spot dorsolaterally in the middle, both of which are connected discally by a transverse interrupted scale line. Dorsally at base another triangular spot. Elytra strongly striate-punctate, each elytron with six scale spots, of which one, which takes the place of the heart-shaped sutural spot of *roseomaculatus*, is a transverse spot located more dorsolaterally.

Length, 12 millimeters; width, 5.

Philippines, exact locality unknown.

Waterhouse, in his original description,[44] mentions the possibility that *P. striatus* is only a variation of *P. roseomaculatus*.

[44] Trans. Ent. Soc. London I 3 (1843) 317.

Sp. 12. Pachyrrhynchus striatus, Waterh.

Ater; elytris profundè punctatato-striatis; capite maculâ inter oculos; thorace suprà trimaculato; elytris duodecim-maculatis; maculis aureis; illis elytrorum ad basin quatuor, et ad apicem quatuor elongatis, ad medium quatuor, scilicet duabus externis rotundatis, et duabus dorsalibus transversis.

Long. corp. 6 lin., lat. 2 ⅔ lin.

This species is rather smaller than *P. moniliferus*, and of a narrower form. It is most nearly related to *P. roseo-maculatus*, and very nearly resembles that insect in its markings, but here they are of a golden hue, and instead of the cordiform spot on the suture there are two transverse spots, one on each side, at a short distance from the suture. The elytra are deeply punctate-striated. On the upper surface of the thorax are three spots, one behind, which is triangular, and one on each side; these last are joined by a narrow subinterrupted transverse line. It is possible this may only be a variety of the *roseo-maculatus;* but the difference in sculpture and size, as well as there being two transverse spots distant from the suture in lieu of the cordiform spot on the suture, caused me to separate it. In the present group, however, I have found considerable difference in the sculpturing of specimens of the same species, and the markings in some are subject to extraordinary variations; that is, if I am right in supposing all those insects as varieties of *P. orbifer* which I have given as such.

Since I know *P. striatus* Waterh. only from the description, I am unable to decide this point.

Pachyrrhynchus roseomaculatus Waterh. Plate 1, fig. 30 (lateral view); Plate 9, fig. 1.

Pachyrrhynchus roseomaculatus WATERH., Proc. Ent. Soc. London (1841) 19; Trans. Ent. Soc. London I 3 (1843) 318; SCHOENH., Gen. Curc. Suppl. 8 (1845) 384; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Black, moderately shiny, with pink scale spots. Rostrum in basal half with a moderately pronounced triangular depression. Head scatteredly punctured, with a large oval scale spot on front and another at sides of head. Prothorax as long as broad, finely and scatteredly punctured, a small roundish scale spot in the middle toward each side, a large spot dorsally at base and a longitudinal patch at each lateral margin. Elytra with regular and well-pronounced rows of punctures and eleven large pink scale spots as follows: A sutural bifid spot in the middle, each elytron with two oblong-oval spots at base, a large roundish spot laterad in the middle, and two very large oblong-oval spots in apical third, one of the latter being located at the outer margin. Underside of mesothorax, metathorax, and first abdominal sternite with a spot laterally. Femora with a spot on underside near apex.

Male, length, 12.7 millimeters (without rostrum); width, 5.8.

LUZON (?). The only specimen in my collection I received in exchange, without exact locality.

This somewhat isolated species is easily recognized by the peculiar markings. In general form it resembles *P. rugicollis* Waterh.

Pachyrrhynchus rugicollis Waterh. Plate 3, fig. 3 (lateral view); Plate 5, fig. 16, ♀.

Pachyrrhynchus rugicollis WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 220; Trans. Ent. Soc. London I 3 (1843) 323; SCHOENH., Gen. Curc. Suppl. 8 (1845) 386; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Var. *crucifer* Heller, loc. cit.

Var. *aurinius* Heller, op. cit. 19 (1921) 544.

Head and prothorax black, elytra dull, dark pitch brown, legs bluish black, glossy. Rostrum in apical half strongly and remotely punctate, basal half with well-pronounced triangular dorsal depression. Front finely punctate with a small oblong scale spot. Prothorax slightly broader than long, with more or less

confluent coarse rugosities beset with reddish golden scales having a luster like mother of pearl. Elytra finely coriaceous, very indistinctly striate-punctate, basal and apical fourths with coarse rugosities beset with scales. Mesosternum and metasternum and first abdominal segment with a scale patch laterally. Femora with a scale spot near apex. Penis structure, Plate 3, fig. 30.

Male, length, 8.5 to 12 millimeters (without rostrum); width, 4.5 to 5.5. Female, length, 12 to 12.5 millimeters (without rostrum); width, 6.2 to 6.6.

LUZON, Zambales Province, Iba: Bataan Province, mountains of Mariveles (*Schultze*).

In the var. *crucifer* Heller, the scaled rugosities on prothorax dorsally are somewhat concentrated so as to form a figure approximately like a ✠. The var. *aurinius* Heller refers to a perfectly fresh specimen in which the scales possess in a marked degree the peculiar color and luster of mother of pearl. This coloration, as well as a certain opalescent sheen of the scale markings of many other species of the genus, mostly disappear owing to post-mortem changes.

Pachyrrhynchus sphaericollaris sp. nov. Plate 3, fig. 7, ♂ (lateral view); Plate 6, fig. 12.

Very glossy, dark purplish coppery, without any scale markings. Apical half of rostrum strongly swollen, basal half flat depressed, with a very shallow triangular depression and a strongly pronounced medial groove reaching to front. A small patch of short creamy white hair at sides of head below eye. Prothorax slightly broader than long, subspherical, glossy and impunctate, except a small depression with a few scattered and rather coarse punctures in the middle at each lateral margin. A well-pronounced anterior submarginal groove. The marginal area set off by the latter slightly swollen. Elytra very short ovate, dorsally and laterally strongly and uniformly inflated, with almost obsolete rows of punctures dorsolaterally. A well-pronounced submarginal puncture row from middle to apex, the punctures getting coarser near apex. Near the latter two other abbreviated coarse puncture rows also strongly pronounced, forming groovelike impressions, the interstices forming swollen ridges. Underside and tarsi bluish black.

Male, length, 13.5 millimeters (without rostrum); width, 6.5.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*).

This remarkable species I place for the present in the *P. moniliferus* group. It is easily recognized by the very distinctly subspheric prothorax, very short ovate elytra, and peculiar coloration. The legs, particularly the tibiæ, are also relatively longer than in any other species of this group but not so slender as in species belonging to the *P. anellifer* group.

Pachyrrhynchus halconensis Schultze. Plate 2, fig. 10 (lateral view); Plate 9, fig. 9, ♀.

Pachyrrhynchus halconensis SCHULTZE, Philip. Journ. Sci. 21 (1922) 577, pl. 2, fig. 3.

Black; moderately glossy, with metallic pale green (male) or coppery micaceous (female) scale markings. Related to *P. phaleratus* Waterh. Rostrum toward apex strongly divergent, in apical half scatteredly punctured, in basal half with a strongly pronounced triangular depression beset with a large scale spot. Front with a triangular spot and sides of head with another spot. Prothorax a little broader than long, very minutely and scatteredly punctured. A crossband, which is sometimes interrupted before the middle, branches laterally, one branch running obliquely toward the anterior and the other toward the posterior margin, both are continued as a lateral marginal stripe and circumscribe the sides. Dorsally in the middle at hind margin a large oblong triangular spot. Elytra in the male oblong, in the female short ovate, the surface very finely coriaceous with very faint traces of puncture rows. A broad irregular crossband in the middle, dorsally in basal half an abbreviated stripe which is continued as a broad basal and marginal stripe to apex. At the latter place it is expanded as a large patch, especially in the female, from which a narrow longitudinal stripe extends forward to crossband. The female mostly has in apical half of elytra an interrupted subsutural stripe. Underside, mesosternum, metasternum, and first abdominal sternite laterally with a scale spot. Femora with a ring spot near apex, interrupted above. Penis structure, Plate 3, fig. 25.

Male, length, 13.6 millimeters (without rostrum); width, 6. Female, length, 17 millimeters (without rostrum); width, 7.8.

MINDORO, subranges of Mount Halcon.

This species is variable in respect to the markings. In the male the longitudinal stripe in apical half of each elytron is abbreviated and does not reach to crossband.

Pachyrrhynchus jugifer Waterh. Plate 2, fig. 7 (lateral view); Plate 5, fig. 1, ♀.

Pachyrrhynchus jugifer WATERH., Proc. Ent. Soc. London (1841) 20; Ann. Mag. Nat. Hist. I 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 319; SCHOENH., Gen. Curc. Suppl. 8 (1845) 384; HELLER, Philip. Journ. Sci. § D 7 (1912) 310; SCHULTZE, Philip. Journ. Sci. 13 (1918) 374.

Pachyrrhynchus rhodopterus CHEVR., Rev. Zool. (1841) 224; SCHOENH., Gen. Curc. 8 (1845) 384.

Head, prothorax, and legs bluish black with metallic greenish golden scale markings. Elytra black, the larger part of the surface covered by pink scales. Rostrum in basal half with an oblong triangular depression and a longitudinal median groove. Front with an oblong scale spot. Another spot at side of rostrum and head. Prothorax as broad as long, the sides evenly rounded. The side areas beset with a large patch of scales, dorsally connected by an irregular more or less interrupted medial crossband. Prothorax dorsally, aside from the crossband, with a large triangular spot in the middle at base, which extends to former. Thus, three bare areas are set off dorsally, one in apical half and two in basal half. Elytra black, with well-pronounced rows of punctures, the entire surface beset with pink scales with the exception of the following bare spots and markings: A roundish sutural spot near base, and an irregular crossband at middle. Fore margin of band forms a wavy, hind margin an irregular zigzag line, band spotlike expanded at suture and a narrow sutural stripe is formed in some specimens which becomes confluent with a small bare roundish area at apex. All margins of the bare areas are surrounded by a fine line formed of golden metallic scales, which contrast with the pink scale coloration. Femora with a ring spot near apex.

Male, length, 12.5 millimeters (without rostrum); width, 5.5. Female, length, 11.5 millimeters (without rostrum); width, 5.2.

PANAY, Jamindan and Mount Macosolon (*Schultze*).

This species is related to *P. orbifer* Waterh., but seems to be confined to the above-mentioned island.

Pachyrrhynchus reticulatus Waterh. Plate 2, fig. 28, ♀ (lateral view); Plate 5, fig. 6, ♀.

Pachyrrhynchus reticulatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 322; SCHOENH., Gen. Curc. Suppl. 8 (1845) 386; HEYDEN, Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 4; HELLER, Philip. Journ. Sci. § D 7 (1912) 310, 323.

Black; prothorax and elytra with pale yellowish green scale stripes forming a net or mesh design. Rostrum in basal half with an oblong depression and indistinct medial groove. In the depression an elongate triangular scale spot reaching to front. Sides of rostrum and head with a scale stripe. Prothorax as long as broad, with a scale line along anterior margin and a combination of curved stripes which circumscribe dorsally five bare areas, two at the anterior margin which are more or less confluent, two at the posterior margin, and a small squarish area discally. The lateral margins also circumscribed by stripes. Elytra very regularly striate-punctate. Each elytron divided by diagonal stripes into nine irregular bare areas, and two additional sutural areas at base and behind the middle are common to both elytra. Prosternum with a scale stripe at anterior and posterior margins and in the middle, mesosternum with a crossband and spots laterally, metasternum also with spots laterally, and first abdominal sternite with a broad crossband. The last abdominal sternite very coarsely punctate and scatteredly scaled. Legs black, femora with a scale spot near apex. Penis structure, Plate 3, fig. 32.

Male, length, 12 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 7.

LUZON, Laguna Province, Lilio and Paete (*Schultze*).

This species is rather variable; specimens which I consider as typical in accordance with the Waterhouse description, for part of which see footnote,[45] were collected at the aforementioned locality; but among these specimens are some with red or reddish brown femora. Other specimens which I received from Luzon, Camarines Sur Province, Isarog Volcano, differ from the typical form, since the stripe markings are reduced to fine and narrow scale lines, the color of which is golden green. Still other specimens I designate herewith as—

[45] Sp. 19. Pachyrrhynchus reticulatus, Waterh.

Niger; capite lineis tribus longitudinalibus notate; thorace elytrisque lineis aureo-viridibus vel cupreis areas polygonas circumdantibus reticulate' ornatis; and the following passage from the English description "—The upper surface of the thorax is divided into five areas by coloured lines,—two areas in front, which are more or less confluent, two behind, and a small central one; and on each side of the thorax there is moreover a large inclosed area."

Pachyrrhynchus reticulatus subsp. cruciatus subsp. nov. Plate 2, fig. 29 (lateral view); Plate 5, fig. 3.

Black; prothorax and elytra with narrow scale lines. On the dorsal part of prothorax the lines form the figure ✢. Elytra with the lines circumscribing the bare areas not crossing at distinct angles, but forming transverse loops.

LUZON, Tayabas Province, Baler (*Schultze*).

Pachyrrhynchus reticulatus Waterh. seems to be confined to Luzon.

Pachyrrhynchus circulatus Heller. Plate 2, fig. 27 (lateral view); Plate 5, fig. 7, ♀.

Pachyrrhynchus circulatus HELLER, Philip. Journ. Sci. § D 7 (1912) 322, pl. 2, fig. 12; SCHULTZE, op. cit. 21 (1922) 593, pl. 3, fig. 19 (penis structure).

Black, with pale greenish yellow scale line markings. Rostrum in apical half densely punctured, basal half with a rather flat depression. Front with a scale line forming a small rectangle. Prothorax as long as broad, discally with an indistinct medial groove. A scale line forming dorsally a reversed pear-shaped figure and confluent with lines at the lateral margins which form an irregular, distorted ring design. Elytra regularly striate-punctate. Each elytron with five more or less ring-shaped figures, two at base which usually touch each other, two others slightly behind the middle are well separated, and a large ring-shaped figure near apex. The latter is connected by a marginal line with the outer ring in the middle. Underside black, prosternum with a scale line in the middle and at fore and hind margins, mesosternum with a small ring spot laterally connected by a crossband. Metasternum with a spot laterally, first abdominal sternite with a broad crossband, and last sternite with a scale patch laterally. Femora with a scale band interrupted above, near apex. Penis structure, Plate 3, fig. 31.

Male, length, 10.5 millimeters (without rostrum); width, 5. Female, length, 12.5 millimeters (without rostrum); width, 6.

CATANDUANES, Virac (*Anacleto Duyag*).

My collector obtained numerous specimens of this species from the above locality only. The specimens show very little variation. Heller considered this species as closely related to *P. reticulatus* Waterh. which fact seems to be substantiated by

certain similarities in the penis structure. Its relation to some other species and the relation of those species to each other, are well demonstrated on Plate 2, figs. 21 to 29, which shows the following species, together with the localities in which they were found:

Fig. 21. *Pachyrrhynchus absurdus* Schultze, Bucas Grande Island.
22. *Pachyrrhynchus postpubescens* Schultze, Mindanao Province, Bukidnon.
23. *Pachyrrhynchus speciosus* Waterh., Mindanao; Bucas; Siargao; Dinagat.
24. *Pachyrrhynchus samarensis* sp. nov., Samar.
25. *Pachyrrhynchus regius* Schultze, Leyte.
26. *Pachyrrhynchus latifasciatus* Waterh., exact locality unknown.
27. *Pachyrryhynchus circulatus* Heller, Catanduanes.
28. *Pachyrrhynchus reticulatus* Waterh., Luzon, Laguna Province.
29. *Pachyrrhynchus reticulatus* subsp. *cruciatus* subsp. nov., Luzon, Tayabas Province.

All these species show very distinctly their common ancestry; they also show their divergent development, due to long geographic isolation, into well-separated and distinct species.

GROUP II

Group II is typified by *Pachyrrhynchus speciosus* Waterh. Body form mostly very similar to that of the species of the *P. moniliferus* group. General color dark glowing red, coppery, or dark green. Prothorax and elytra very strikingly marked with narrow scale stripes, bands, or ring figures.

Key to the species of Pachyrrhynchus, Group II.

a^1. Prothorax dorsally with two longitudinal scale lines, or an arrow-shaped figure.
b^1. Prothorax dorsally with two longitudinal scale lines, divergent at base, convergent toward and confluent at anterior margin. **P. postpubescens Schultze.**
b^2. Prothorax dorsally with scale lines forming a more or less slender arrow-shaped figure.
c^1. Elytra with narrow or very broad band markings.
d^1. Elytra with very narrow crossbands..... **P. speciosus Waterh.**
d^2. Elytra with three very broad crossbands, first and third interrupted at suture..... **P. samarensis Schultze.**
c^2. Elytra with large irregular ring figures..... **P. regius Schultze.**
a^2. Prothorax dorsally with two subparallel transverse scale lines or a transverse band.
e^1. Prothorax with two subparallel transverse scale lines. **P. absurdus Schultze.**
e^2. Prothorax with a broad transverse band which is discally narrow and divergent toward the sides..... **P. latifasciatus Waterh.**

Pachyrrhynchus speciosus Waterh. Plate 2, fig. 23, ♂ (lateral view); Plate 4, fig. 6.

Pachyrrhynchus speciosus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 314; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 311.

Pachyrrhynchus absurdus SCHULTZE, Philip. Journ. Sci. 15 (1919) 550, pl. 1, fig. 4 (male); HELLER, Entomol. Mitteil. 10 (1921) 196.

Glossy dark glowing red, or like burnished copper, old specimens almost black, with pale green scale markings. Rostrum in basal half with an oblong shallow depression reaching to front and beset with an elongate scale spot. Sides of head and rostrum with another scale patch. Prothorax slightly longer than broad, very finely punctate. Dorsally in the middle two longitudinal scale stripes, convergent toward and confluent near anterior margin, forming a narrow or broad arrow-shaped figure. The lateral margins circumscribed by a scale band forming a large oval figure. Elytra short ovate, striate-punctate. Each elytron in basal third with a transverse oval figure circumscribed by a narrow scale band reaching from first puncture row to lateral margin. In the middle two narrow parallel transverse bands which are confluent at margin with a marginal stripe, the latter of which circumscribes in apical third a triangular figure. Prosternum, mesosternum, and metasternum beset with scales, first and second abdominal sternites with a large scale patch laterally. Femora with a scale spot near apex.

Male, length, 10.5 millimeters (without rostrum); width, 5.2. Female, length, 12 millimeters (without rostrum); width, 6.

MINDANAO, Surigao Province, Surigao. SIARGAO, BUCAS GRANDE, and DINAGAT (*Schultze*). MINDANAO, Cotabato Province, Saob (*Taylor*). BOHOL, Bilar (*A. Duyag*).

In this species the dorsal arrow-shaped marking on prothorax is variable, in some specimens (from Siargao) rather broad, in others (from Cotabato) very slender, forming almost a straight confluent, anteriorly pointed stripe.

Pachyrrhynchus regius Schultze. Plate 2, fig. 25 (lateral view); Plate 9, fig. 14.

Pachyrrhynchus regius SCHULTZE, Philip. Journ. Sci. 21 (1922) 579, pl. 2, fig. 6, ♀.

Glossy dark glowing red, elytra with large roundish yellowish green annular or ring markings. Rostrum in basal half with a strongly pronounced depression and a fine medial groove, extending to front. The latter with an oblong scale spot. Sides

of rostrum and head with a patch of scales. Prothorax as long as broad, the sides moderately rounded. Dorsally in the middle a longitudinal arrow-shaped marking. Lateral margins with a broad irregular oblong-oval ring marking. Elytra striate-punctate. Each elytron with a very large irregularly roundish ring marking at base, reaching from first puncture row to lateral margin, in the middle a cross row of two other, smaller, and in apical third a larger ring marking. The middle ring marking located near lateral margin is connected with the one in apical third by a broad stripe along margin. The scaled areas on prothorax and elytra are distinctly impressed on the surface. Prosternum, mesosternum, and metasternum beset with scattered scales, first and second abdominal sternites with a scale spot laterally. Femora with a small spot on underside near apex.

Male, length, 12.3 millimeters (without rostrum); width, 5.5. Female, 13 millimeters (without rostrum); width, 6.

LEYTE, mountains near Cabalian (*Gregorio Lopez*).

Pachyrrhynchus postpubescens Schultze. Plate 2, fig. 22, ♂ (lateral view); Plate 4, fig. 4, ♂.

Pachyrrhynchus postpubescens SCHULTZE, Philip. Journ. Sci. 21 (1922) 578.

Glossy dark coppery red, prothorax with pale green longitudinal scale stripes, elytra with markings very similar in design to *P. speciosus* Waterh. Rostrum in basal half with a strongly pronounced dorsal depression, the dorsolateral edges of rostrum distinctly swollen. Front with an oblong-oval scale ring marking, sides of head with a spot below eye. Prothorax almost as broad as long, the greatest width behind middle, dorsally two longitudinal stripes convergent toward anterior margin. Sides with two broad longitudinal stripes which are more or less confluent at anterior and posterior margins. Elytra striate-punctate, the punctures rather large. Each elytron in basal third with a band forming crosswise an irregularly oval figure, reaching from first puncture row to lateral margin. In middle of elytra two crossbands which curve backward on sides and circumscribe a roughly triangular figure in apical third of each elytron. Apical third of elytra scanty pubescent. Prosternum, mesosternum, metasternum, and first and second abdominal sternites more or less densely beset with scattered scales. Femora with a scale spot on underside near apex.

Male, length, 13 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 6.6.

MINDANAO, Bukidnon Province, Lindabon (*Schultze*).

Pachyrrhynchus samarensis sp. nov. Plate 2, fig. 24, ♂ (lateral view); Plate 9, fig. 18.

Glossy coppery red with pale green scale markings. Related to *P. speciosus* Waterh. Rostrum in basal half with an oblong triangular depression and an oblong scale spot on front. Another scale spot on sides of head. Prothorax as broad as long, dorsally in the middle with a large oblong scale patch, reaching from anterior to posterior margin. A large scale patch entirely covers sides of prothorax. Elytra with regular and well-pronounced rows of punctures. Each elytron with a large scale patch at base, reaching from first row to lateral margin. In the middle a broad crossband and in apical fourth a large triangular patch which is narrowly connected along lateral margin with crossband. Femora with some scattered scales apically on underside.

Male, length, 10.5 millimeters (without rostrum); width, 5.

SAMAR, Catarman (*R. L. Frost*).

Pachyrrhynchus absurdus Schultze. Plate 2, fig. 21 (lateral view); Plate 4, fig. 5, ♀.

Pachyrrhynchus absurdus SCHULTZE, Philip. Journ. Sci. 15 (1919) 550, pl. 1, figs. 3, 3*a*, ♀.

Dark, glossy, glowing red, with bands of pale green scales. Rostrum sparsely punctured, with a strongly pronounced, oblong depression from the middle extending to front, where it becomes shallow. The depression with an oblong pale green scale spot. Another spot at each side of head. Prothorax slightly broader than long, with an indistinct anterior submarginal groove and a strongly pronounced posterior submarginal groove. Female with a pair of subparallel transverse bands across disk, from one lateral margin to the other. Elytra of female one-half longer than broad, apically terminating in a prolonged thorn, which is slightly bent downward. Elytra punctate-striate. Female with two pairs of subparallel bands across disk from one lateral margin to the other, and at apical third another band forming a triangle. The basal pair of bands interrupted at suture, but confluent along lateral margin. The anterior and posterior bands of second pair curved backward at and near lateral margin; they recurve so as to form the triangular figure

apically. A scale spot on each femur near apex, below. Posterior femora of female not reaching beyond apex of elytra.

Female, length, 15.8 millimeters; width, 6.8.

BUCAS GRANDE (*Schultze*).

Pachyrrhynchus latifasciatus Waterh. Plate 2, fig. 26 (lateral view); Plate 9, fig. 17.

Pachyrrhynchus latifasciatus WATERH., Proc. Ent. Soc. London (1842) 45; Trans. Ent. Soc. London I 3 (1843) 317; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 311; SCHULTZE, Philip. Journ. Sci. 23 (1923) 78.

Glossy dark green, prothorax and elytra with pale greenish crossbands. Rostrum in apical half strongly bulging, basal half with a rather shallow impression and a longitudinal groove. Prothorax slightly broader than long, subglobular, with a crossband in the middle which is narrow discally, becoming wider toward lateral margins. Elytra with very regular, strongly pronounced rows of punctures and a crossband near base, another slightly broader at middle; both these bands are interrupted at suture and the second is curved on the side of elytra and runs backward along margin. Each elytron in apical third with a large oblong spot parallel to suture and two smaller, more roundish spots laterally.

Male, length, 12.5 millimeters (without rostrum); width, 5.8.

Philippines, exact locality unknown.

The description is taken from a specimen loaned by the British Museum.

Pachyrrhynchus latifasciatus Waterh. represents a somewhat isolated species of the genus, but seems to be most closely related to some of the *P. speciosus* group.

GROUP III

Group III comprises two of the extra-Philippine species, *Pachyrrhynchus morotaiensis* Vollh. and *P. forsteni* Vollh. Both species are quite different from any of the Philippine groups, but come closest in general appearance to some of the *P. moniliferus* group.

Key to the species of Pachyrrhynchus, Group III.

a^1. General color bluish black. Elytra with white scale spots forming cross rows. The spots in the middle row approaching each other very closely, thus forming an interrupted crossband. **P. forsteni** Vollh.

a^2. General color black. Elytra with a cork-colored crossband at base and in the middle..... **P. morotaiensis** Vollh.

Pachyrrhynchus morotaiensis Vollh. Plate 3, fig. 39 (lateral view); Plate 8, fig. 9.

Pachyrrhynchus morotaiensis VOLLH., Tijdschr. v. Ent. 7 (1864) 169; HELLER, Philip. Journ. Sci. § D 7 (1912) 305.
Pachyrrhynchus waterhousei FAUST, Stett. Ent. Zeitg. (1895) 95.

Black glossy; prothorax and elytra with pale cork-colored scale markings. Rostrum in basal half with a shallow depression beset with a large scale spot. Prothorax broader than long with a scale stripe along anterior and posterior margins, both stripes confluent at lateral margin. Elytra oblong-ovate with rudimentary indicated rows of punctures which are somewhat more strongly pronounced near lateral margin and apex. Each elytron with a narrow crossband at about basal fourth, reaching from first puncture row to lateral margin. A second crossband in the middle more or less interrupted at suture. Apical fourth with two lateral scale spots and a more or less interrupted longitudinal stripe in third interstice. Underside, mesosternum, metasternum, and first abdominal sternite with scattered scales and finely whitish setose. Legs sparsely setose.

Male, length, 11 millimeters (without rostrum); width, 4.8.

MOROTAI, Moluccas.

This species is nearly related to *P. forsteni* Vollh.

Pachyrrhynchus forsteni Vollh. Plate 3, fig. 40 (lateral view); Plate 8, fig. 8.

Pachyrrhynchus forsteni VOLLH., Tijdschr. v. Ent. 7 (1864) 168, pl. 12, fig. 4; HELLER, Philip. Journ. Sci. § D 7 (1912) 305.

Glossy bluish black; prothorax and elytra with white scale spots. Rostrum in apical half scatteredly punctured, basal half with a shallow oblong depression beset with a scale spot. Head distantly scatteredly punctured. Prothorax slightly longer than broad, very finely and scatteredly punctured, at anterior and posterior margins dorsolaterally with a small lateral scale spot and two not sharply defined spots in the middle at lateral margins. Elytra oblong-ovate, indistinctly striate-punctate, with four cross rows of small white scale spots. The first cross row, located at basal fourth, consists of four spots on each elytron, one of them dorsally, the others laterally; the second cross row, located in the middle, has seven or eight spots placed close together which do not reach suture or lateral margin. The third cross row, at apical third, consists of three spots and the fourth row is a transversely expanded spot next to apex. Legs sparsely and finely whitish setose.

Length, 12.5 millimeters (without rostrum); width, 5.5.

TERNATE; HALMAHERA; SUMATRA.

Pachyrrhynchus forsteni Vollh. is closely related to none of the Philippine *Pachyrrhynchus* species in the sense that *P. infernalis* Fairm. is to *P. orbifer* Waterh.; its nearest relative is *P. morotaiensis* Vollh., and these two are somewhat isolated representatives of the genus.

GROUP IV

Group IV is typified by *Pachyrrhynchus schoenherri* Waterh. and comprises relatively small species. The following species are placed in this group: *Pachyrrhynchus schoenherri* Waterh., *P. apocyrtoides* Schultze, *P. signaticollis* Schultze, *P. bucasanus* Schultze, *P. signatus* Schultze, *P. erichsoni* Waterh., and *P. semiignitus* Schultze.

Key to the species of Pachyrrhynchus, Group IV.

a^1. Elytra with distinct and well-defined roundish spots, not confluent, and without stripes.

b^1. Prothorax with two more or less roundish spots dorsolaterally in the middle, one toward each side.

b^2. Prothorax with a dorsally interrupted transverse band in the middle. **P. signaticollis** Schultze.

c^1. Prothorax without a scale line dorsally at anterior and posterior margins; spots on elytra small.

c^2. Prothorax with a scale line dorsally at anterior and posterior margins; spots on elytra large..... **P. bucasanus** Schultze.

d^1. Elytra without any sutural spots.

d^2. Elytra with two sutural spots and eight more on each elytron; general color of elytra glowing red..... **P. schoenherri** Waterh.

e^1. Elytra glossy dark green or coppery red with sixteen spots. **P. erichsoni** Waterh.

e^2. Elytra rather dull black, usually with eighteen spots. **P. erichsoni eschscholtzi** Waterh.

a^2. Elytra with ill-defined spots or more or less abbreviated longitudinal or transverse stripes.

f^1. Elytra without a sharply defined transverse stripe in the middle.

f^2. Elytra with a sharply defined transverse stripe or band in the middle; general color dark purplish violet. **P. signatus** Schultze.

g^1. General color black; prothorax with a spot toward each side in the middle, dorsolaterally; elytra with the spots not sharply defined..... **P. apocyrtoides** Schultze.

g^2. General color glossy glowing red; prothorax without any dorsolateral spots; elytra with well-defined spots. **P. semiignitus** Schultze.

Pachyrrhynchus schoenherri Waterh. Plate 2, fig. 3 (lateral view); Plate 9, fig. 6.

Pachyrrhynchus schoenherri WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 315; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 307; SCHULTZE, Philip. Journ. Sci. 23 (1923) 78.

Glossy glowing red, prothorax and elytra with pale greenish scale spots. Related to *P. erichsoni* Waterh. Rostrum with a rather strongly pronounced depression in basal half, which extends almost to front. The latter with a roundish scale spot and another spot below each eye. Prothorax less subglobular than in *P. erichsoni*, with a small spot in the middle laterad and a larger spot at each lateral margin. Elytra with very faint traces of puncture rows. Each elytron with ten scale spots; two at base, three forming a cross row at the middle, one very large spot at the lateral margin, and two spots at apical third. Also a bifid sutural spot beyond the middle and another at apical fourth.

Female, length, 11 millimeters (without rostrum); width, 5.

Philippines, exact locality unknown.

This description is taken from a cotype specimen loaned by the British Museum.

Pachyrrhynchus erichsoni Waterh. Plate 3, fig. 1 (lateral view); Plate 9, fig. 15.

Pachyrrhynchus erichsoni WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 315; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 307, pl. 1, fig. 19; SCHULTZE, op. cit. 21 (1922) pl. 4, fig. 7.

Var. *chrysocompsus* HELLER, loc. cit.

Head, prothorax, and legs dark coppery red; elytra glossy, bronze or brass green in color. Prothorax and elytra with small roundish pale yellowish green scale spots. Rostrum, basal half with a shallow depression and strongly defined medial groove reaching to front, the latter with a scale spot. Sides of head with a scale spot below eye. Prothorax subglobular with a round scale spot in the middle toward each side and another at lateral margin. Elytra ovate, regularly and rather coarsely striate-punctate. Each elytron with eight roundish scale spots, two of which form a cross row near base, two in the middle, three in apical fourth, and one near apex. Mesosternum and

metasternum with a scale spot laterally. Penis structure, Plate 3, fig. 33.

Male, length, 9.5 to 13 millimeters (without rostrum); width, 4.5 to 5.6. Female, length, 12.5 millimeters (without rostrum); width, 6.

MINDANAO, Surigao Province, Surigao. DINAGAT (*my collector*). LEYTE, Cabalian (*Gregorio Lopez*). One specimen, from Leyte, has the general color of the elytra reddish coppery.

Specimens from the first two localities here given I consider typical, since they agree perfectly with the Waterhouse description, particularly with this author's remark that "it may be distinguished from either of the other species by its brass green color." Heller placed *P. eschscholtzi* Waterh. as a synonym of *P. erichsoni*, under the impression that it represented the female of *P. erichsoni*. I cannot agree with this since both sexes of the last-named species show the same general coloration, the same number of spots, as well as other small but constant differences in the form of the prothorax and elytra in comparison to *P. eschscholtzi*. Furthermore, the penis structures show that this organ in *P. erichsoni* is broader toward the point. For these reasons *P. eschscholtzi* is to be considered as a well-distinguished local race or subspecies of *P. erichsoni* Waterh.

Pachyrrhynchus erichsoni subsp. **eschscholtzi** Waterh. Plate 5, fig. 4.

Pachyrrhynchus eschscholtzi WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 316; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 307, pl. 1, fig. 20.

Black; prothorax glossy. Each elytron with eight to ten yellowish green or pale flesh-colored scale spots. Two form a cross row at base, two or three in the middle, three or four in apical fourth, and one near apex.

Male, length, 10 to 10.5 millimeters (without rostrum); width, 4.8 to 5. Female, length, 12.5 millimeters; width, 5.8.

LUZON, Laguna Province, Paete, Mount Banahao. POLILLO (*Schultze*).

Var. *chrysocompsus* Heller has the dorsolateral spots of prothorax modified, forming reverse comma-shaped spots, the pointed end being slightly curved.

Pachyrrhynchus erichsoni and subspecies *eschscholtzi* seem to have the largest range of distribution of any species of the genus. It seems probable that further local races of *P. erich-*

soni will be found in such intermediate islands as Samar and Catanduanes, between Mindanao and Luzon.

Pachyrrhynchus signatus Schultze. Plate 2, fig. 4, ♀ (lateral view); Plate 5, fig. 13.

Pachyrrhynchus signatus SCHULTZE, Philip. Journ. Sci. 15 (1919) 551, pl. 1, figs. 6, 6*a*.

Dark, glossy, iridescent, violet purplish with pale green markings, rostrum and legs metallic copper colored. Closely related to *P. erichsoni* Waterh. Head with a small scale spot under each eye. Prothorax with a narrow anterior marginal band, another somewhat broader band at the middle interrupted discally, and traces of a posterior marginal band. Elytra with rows of distinct punctures. Each elytron with two large oblong-oval spots near base, one located discally, the other at lateral margin; at the middle a crossband, reaching from first row of punctures to eighth near lateral margin. At apical third a longitudinal stripe at third interstice, reaching to apex, recurving as a submarginal stripe, thus forming roughly a triangle, inside of which are located two oblong spots at fifth and seventh interstices, respectively.

Length, 11.6 millimeters; width, 5.5.

SIARGAO (*Schultze*).

Pachyrrhynchus bucasanus Schultze. Plate 2, fig. 1, ♀ (lateral view); Plate 5, fig. 10, ♀.

Pachyrrhynchus bucasanus SCHULTZE, Deutsche Ent. Zeitschr. (1922) 40, pl. 1, fig. 11, ♀.

Related to *P. erichsoni* Waterh. but much stouter in build. Glossy, dark wine red with violet sheen and pale yellowish green scale markings. Rostrum very similar to that of *P. apocyrtoides*, basal half depressed and flattened with a short but strongly pronounced longitudinal medial groove. A scale spot at sides of head. Prothorax as long as broad, with an anterior submarginal stripe and a short abbreviated posterior submarginal stripe dorsally. In the middle but toward each side a rather large irregular scale spot and a large roundish spot at each lateral margin. Elytra rather short ovate, strongly inflated, with moderately pronounced but regular rows of punctures. Each elytron with nine scale spots, forming cross rows, two at base, two in the middle, four others forming a cross row at apical third, and one, which is triangular, near apex. Legs metallic copper colored.

Female, length, 13 millimeters (without rostrum); width, 6.5.

BUCAS GRANDE (*Schultze*).

The spots in this species are much larger than in any other of the *P. erichsoni* group; also, it is one of the shortest and stoutest species of the genus.

Pachyrrhynchus signaticollis Schultze. Plate 1, fig. 28 ♂ (lateral view); Plate 9, fig. 2, ♂.

Pachyrrhynchus signaticollis SCHULTZE, Deutsche Ent. Zeitschr. (1922) 41, pl. 1, fig. 13.

Pachyrrhynchus transversarius HELLER, Stett. Ent. Zeitg. 84 (1923) 8.

Related to *P. erichsoni* Waterh. Head, prothorax, and legs glossy, elytra dull black. Rostrum in basal half with an oblong depression reaching to front and a very prominent longitudinal median groove reaching almost to vertex. Prothorax as long as broad, impunctate, with an irregular, pale reddish or pink crossband in the middle, interrupted discally but expanded spotlike at lateral margins. Elytra with regular rows of punctures, the punctures farther apart than in *P. erichsoni*. Each elytron with nine roundish pale reddish or pink scale spots which are placed in three cross rows, two near base, two at the middle, four at apical third, and one at apical triangle.

Male, length, 11 millimeters (without rostrum); width, 4.5.

MINDANAO, Agusan Province, Butuan (*C. M. Weber*).

Pachyrrhynchus apocyrtoides Schultze. Plate 1, fig. 27, ♂ (lateral view); Plate 9, fig. 3, ♂.

Pachyrrhynchus apocyrtoides SCHULTZE, Deutsche Ent. Zeitschr. (1922) 39.

Related to *P. erichsoni* Waterh. Head bluish black, prothorax, elytra, and legs dark brown with a violet sheen. Rostrum divergent toward apex, basal half uniformly depressed with a prominent short longitudinal medial groove. Prothorax glossy, slightly broader than long, with a narrow creamy white anterior submarginal scale stripe which extends to lateral margins, forming a large irregular scale spot. In the middle toward each lateral margin a small roundish spot. Elytra dull, finely coriaceous, with well-pronounced rows of punctures. Each elytron with three groups of irregular crossbandlike scale markings, the edges of which are not sharply defined. Two are located near base, another more fascialike at the middle, and a series of about five spots in apical third.

Male, length, 11 millimeters (without rostrum); width, 4.

MINDANAO, Bukidnon Province (*Schultze*).

Pachyrrhynchus semiignitus Schultze. Plate 1, fig. 22 (lateral view); Plate 9, fig. 12, ♂.

Pachyrrhynchus semiignitus SCHULTZE, Philip. Journ. Sci. 21 (1922) 581, pl. 2, fig. 9, ♂.

Head and prothorax glossy glowing red, elytra and legs metallic coppery. Elytra with pale green scale spots and stripes. Rostrum in apical half coarsely punctured, basal half with a strongly pronounced depression beset with some scattered scales. The dorsolateral edges swollen. Prothorax slightly broader than long, the sides moderately and evenly rounded. A narrow scale line along anterior and posterior margins, both lines confluent with a stripe on lateral margins. Elytra striate-punctate. Each elytron in basal third with a cross row of four larger oblong scale spots, between which are some smaller dots; in apical third between second and third puncture rows a longitudinal stripe confluent at apex with a short marginal stripe, the latter forming a V-shaped figure. Within this triangular figure two small spots form a lateral row. Underside coppery; mesosternum and metasternum with scattered scales and a large spot laterally. Femora with a patch of scattered scales on underside near apex.

Male, length, 11.5 millimeters (without rostrum); width, 5.6.

MINDANAO, Cotabato Province, Pikit.

This is also a somewhat isolated species.

(*To be concluded.*)

ILLUSTRATIONS

[Original black and colored drawings, except Plate 8, by W. Schultze; drawings of Plate 8 by Max Böhme. All colored figures enlarged about x 1.5.]

Plate 1

Fig. 1. *Pachyrrhynchus infernalis* Fairm.
2. *Pachyrrhynchus orbifer* subsp. *azureus* Schultze, male.
3. *Pachyrrhynchus orbifer* Waterh., female.
4. *Pachyrrhynchus moniliferus* Germ., female.
5. *Pachyrrhynchus moniliferus* subsp. *chevrolati* Eyd. and Soul., female.
6. *Pachyrrhynchus zebra* Schultze, female.
7. *Pachyrrhynchus erosus* Schultze, male.
8. *Pachyrrhynchus annulatus* Chevrolat, female.
9. *Pachyrrhynchus annelifer* Heller, female.
10. *Pachyrrhynchus schuetzei* Schultze.
11. *Pachyrrhynchus igorota* Schultze, male.
12. *Pachyrrhynchus inclytus* Pasc., female.
13. *Pachyrrhynchus pulchellus* Behr., female.
14. *Pachyrrhynchus loheri* Schultze, female.
15. *Pachyrrhynchus psittaculus* Heller, female.
16. *Pachyrrhynchus semperi* Heller, female.
17. *Pachyrrhynchus argus* Pasc., female.
18. *Pachyrrhynchus ochroplagiatus* var. *multiplagiatus* var. nov., female.
19. *Pachyrrhynchus gemmatus* Waterh., female.
20. *Pachyrrhynchus congestus* Pasc., female.
21. *Pachyrrhynchus chamissoi* Schultze, female.
22. *Pachyrrhynchus semiignitus* Schultze.
23. *Pachyrrhynchus perpulcher* Waterh., female.
24. *Pachyrrhynchus stellio* Heller, male.
25. *Pachyrrhynchus decussatus* Waterh., female.
26. *Pachyrrhynchus gloriosus* Faust, female.
27. *Pachyrrhynchus apocyrtoides* Schultze, male.
28. *Pachyrrhynchus signaticollis* Schultze, male.
29. *Pachyrrhynchus multipunctatus* Waterh.
30. *Pachyrrhynchus roseomaculatus* Waterh.

Plate 2

Fig. 1. *Pachyrrhynchus bucasanus* Schultze.
2. *Pachyrrhynchus baluganus* sp. nov.
3. *Pachyrrhynchus schoenherri* Waterh.
4. *Pachyrrhynchus signatus* Schultze, female.
5. *Pachyrrhynchus corpulentus* Schultze.
6. *Pachyrrhynchus amabilis* Schultze.

FIG. 7. *Pachyrrhynchus jugifer* Waterh.
8. *Pachyrrhynchus pseudoproteus* Schultze.
9. *Pachyrrhynchus atrocyaneus* Schultze, female.
10. *Pachyrrhynchus halconensis* Schultze, female.
11. *Pachyrrhynchus pinorum* Pascoe.
12. *Pachyrrhynchus consobrinus* Schultze.
13. *Pachyrrhynchus tristis* Heller.
14. *Pachyrrhynchus taylori* subsp. *metallescens* subsp. nov., male.
15. *Pachyrrhynchus taylori* Schultze, female.
16. *Pachyrrhynchus sanchezi* Heller, female.
17. *Pachyrrhynchus apicatus* Schultze.
18. *Pachyrrhynchus confusus* Schultze.
19. *Pachyrrhynchus rufopunctatus* Waterh.
20. *Pachyrrhynchus venustus* Waterh., female.
21. *Pachyrrhynchus absurdus* Schultze, female.
22. *Pachyrrhynchus postpubescens* Schultze.
23. *Pachyrrhynchus speciosus* Waterh., male.
24. *Pachyrrhynchus samarensis* sp. nov.
25. *Pachyrrhynchus regius* Schultze.
26. *Pachyrrhynchus latifasciatus* Waterh.
27. *Pachyrrhynchus circulatus* Heller.
28. *Pachyrrhynchus reticulatus* Waterh.
29. *Pachyrrhynchus reticulatus* subsp. *cruciatus* subsp. nov.
30. *Pachyrrhynchus phaleratus* Waterh., female.

PLATE 3

FIG. 1. *Pachyrrhynchus erichsoni* Waterh., male.
2. *Pachyrrhynchus sarcitis* Behrens, female.
3. *Pachyrrhynchus rugicollis* Waterh.
4. *Pachyrrhynchus sumptuosus* Schultze, female.
5. *Pachyrrhynchus sulphureomaculatus* Schultze.
6. *Pachyrrhynchus morio* Heller, female.
7. *Pachyrrhynchus sphaericollaris* sp. nov., male.
8. *Pachyrrhynchus lorquini* Chevrolat, male.
9. *Pachyrrhynchus chlorites* Chevrolat, male.
10. *Pachyrrhynchus benguetanus* sp. nov.
11. *Pachyrrhynchus ardentius* Schultze.
12. *Pachyrrhynchus libucanus* sp. nov.
13. *Pachyrrhynchus dubiosus* Schultze.
14. *Pachyrrhynchus tristis* Heller.
15. *Pachyrrhynchus ochroplagiatus* Heller.
16. *Pachyrrhynchus venustus* Waterh.
17. *Pachyrrhynchus pinorum* Pascoe.
18. *Pachyrrhynchus congestus* Pascoe.
19. *Pachyrrhynchus congestus* subsp. *coerulans* Kraatz.
20. *Pachyrrhynchus sanchezi* Heller.
21. *Pachyrrhynchus sumptuosus* Schultze.
22. *Pachyrrhynchus igorota* Schultze.
23. *Pachyrrhynchus decussatus* Waterh.
24. *Pachyrrhynchus phaleratus* Waterh.
25. *Pachyrrhynchus halconensis* Schultze.

FIG. 26. *Pachyrrhynchus argus* Pascoe.
27. *Pachyrrhynchus anellifer* Heller.
28. *Pachyrrhynchus moniliferus* Germar.
29. *Pachyrrhynchus orbifer* Waterh.
30. *Pachyrrhynchus rugicollis* Waterh.
31. *Pachyrrhynchus circulatus* Heller.
32. *Pachyrrhynchus reticulatus* Waterh.
33. *Pachyrrhynchus erichsoni* Waterh.
34. *Pachyrrhynchus apicatus* Schultze.
35. *Pachyrrhynchus halconensis* Schultze.
36. *Pachyrrhynchus gloriosus* Faust.
37. *Pachyrrhynchus inclytus* Pascoe.
38. *Pachyrrhynchus pulchellus* Behrens.
39. *Pachyrrhynchus morotaiensis* Vollh.
40. *Pachyrrhynchus forsteni* Vollh.

PLATE 4

FIG. 1. *Pachyrrhynchus ardentius* Schultze, female. Siargao Island.
2. *Pachyrrhynchus corpulentus* Schultze, female. Mindanao, Bukidnon, Lindabon.
3. *Pachyrrhynchus decussatus* Waterh. Catanduanes, Virac.
4. *Pachyrrhynchus postpubescens* Schultze, male. Mindanao, Bukidnon, Lindabon.
5. *Pachyrrhynchus absurdus* Schultze, female. Bucas Grande Island.
6. *Pachyrrhynchus speciosus* Waterh., male. Bucas Grande Island.
7. *Pachyrrhynchus gloriosus* Faust, female. Luzon, Laguna, Mount Banahao.
8. *Pachyrrhynchus gloriosus* var. *abbreviatus* Schultze, male. Luzon, Bontoc.
9. *Pachyrrhynchus ochroplagiatus* Heller, female. Luzon, Benguet, Mount Pulog.
10. *Pachyrrhynchus argus* Pascoe, female. Luzon, Benguet, Mount Santo Tomas.
11. *Pachyrrhynchus pinorum* Pascoe, female. Luzon, Benguet, Atoc.
12. *Pachyrrhynchus pinorum* var. *transversalis* Heller, male. Luzon, Benguet, Atoc.
13. *Pachyrrhynchus inclytus* var. *modestior* Behr., female. Luzon, Benguet, Mount Santo Tomas.
14. *Pachyrrhynchus pulchellus* Behr., female. Luzon, Benguet, Baguio.
15. *Pachyrrhynchus loheri* Schultze, female. Luzon, Bulacan, Mount Guinuisan.
16. *Pachyrrhynchus igorota* Schultze, female. Luzon, Benguet, Pauai (Haight's place).

PLATE 5

FIG. 1. *Pachyrrhynchus jugifer* Waterh., female. Panay, Jamindan.
2. *Pachyrrhynchus zebra* Schultze, female. Luzon, Benguet, Mount Santo Tomas.
3. *Pachyrrhynchus reticulatus* subsp. *cruciatus* Schultze. Luzon, Tayabas, Baler.

FIG. 4. *Pachyrrhynchus erichsoni* subsp. *eschscholtzi* Waterh. Luzon, Laguna, Paete.
5. *Pachyrrhynchus sumptuosus* Schultze, female. Luzon, Kalinga, Lubuagan.
6. *Pachyrrhynchus reticulatus* Waterh., female. Luzon, Laguna, Paete.
7. *Pachyrrhynchus circulatus* Heller, female. Catanduanes, Virac.
8. *Pachyrrhynchus congestus* subsp. *coerulans* Kraatz, female. Luzon, Bontoc, Mount Polis.
9. *Pachyrrhynchus multipunctatus* Waterh. Bohol.
10. *Pachyrrhynchus bucasanus* Schultze, female. Bucas Grande Island.
11. *Pachyrrhynchus orbifer* subsp. *azureus* Schultze. Luzon, Benguet, Kabayan.
12. *Pachyrrhynchus moniliferus* Germ., typical form. Luzon, Rizal, Montalban.
13. *Pachyrrhynchus signatus* Schultze, Siargao Island.
14. *Pachyrrhynchus moniliferus* subsp. *stellulifer*. Mindoro.
15. *Pachyrrhynchus stellio* Heller. Luzon, Bataan, Lamao.
16. *Pachyrrhynchus rugicollis* Waterh., female. Luzon, Zambales, Iba.
17. *Pachyrrhynchus congestus* subsp. *ocellatus* subsp. nov., male. Luzon, Benguet, Bokod.
18. *Pachyrrhynchus moniliferus* subsp. *stellulifer*. Mindoro.
19. *Pachyrrhynchus phaleratus* Waterh., female. Catanduanes, Virac.
20. *Pachyrrhynchus moniliferus* subsp. *chevrolati* Eyd. and Soul. Catanduanes, Virac.

PLATE 6

FIG. 1. *Pachyrrhynchus orbifer* var. *inornatus* Waterh., male. Luzon, Ilocos Norte, Bangui.
2. *Pachyrrhynchus orbifer* var. *circulifer* Chevr., female. Luzon, Ilocos Norte, Bangui.
3. *Pachyrrhynchus orbifer* Waterh. var., female. Luzon, Ilocos Norte, Burgos.
4. *Pachyrrhynchus orbifer* Waterh., female. Luzon, Ilocos Norte.
5. *Pachyrrhynchus orbifer* var. *ardens* Chevr., male. Luzon, Cagayan, Sanchez Mira.
6. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.
7. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.
8. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.
9. *Pachyrrhynchus orbifer* subsp. *gemmans* Chevr., male. Luzon, Cagayan, Tuao.
10. *Pachyrrhynchus orbifer* Waterh. Luzon, Benguet, Baguio.
11. *Pachyrrhynchus orbifer* Waterh. Luzon, Benguet, Baguio.
12. *Pachyrrhynchus sphaericollaris* sp. nov. Luzon, Kalinga, Pinukpuk.
13. *Pachyrrhynchus gemmatus* Waterh., male. Luzon, Benguet, Baguio.

FIG. 14. *Pachyrrhynchus congestus*, Pascoe, female. Luzon, Benguet, Baguio.
15. *Pachyrrhynchus sanchezi* Heller, female. Luzon, Benguet, Baguio.
16. *Pachyrrhynchus sanchezi* Heller, male. Luzon, Benguet, Mount Mirador.
17. *Pachyrrhynchus anellifer* Heller, female. Luzon, Benguet, Irisan River.
18. *Pachyrrhynchus schuetzei* Schultze, female. Luzon, Benguet, Pauai (Haight's place).
19. *Pachyrrhynchus annulatus* Chevr., female. Luzon, Benguet, Mount Pulog.
20. *Pachyrrhynchus erosus* Schultze. Luzon, Benguet, Atoc.

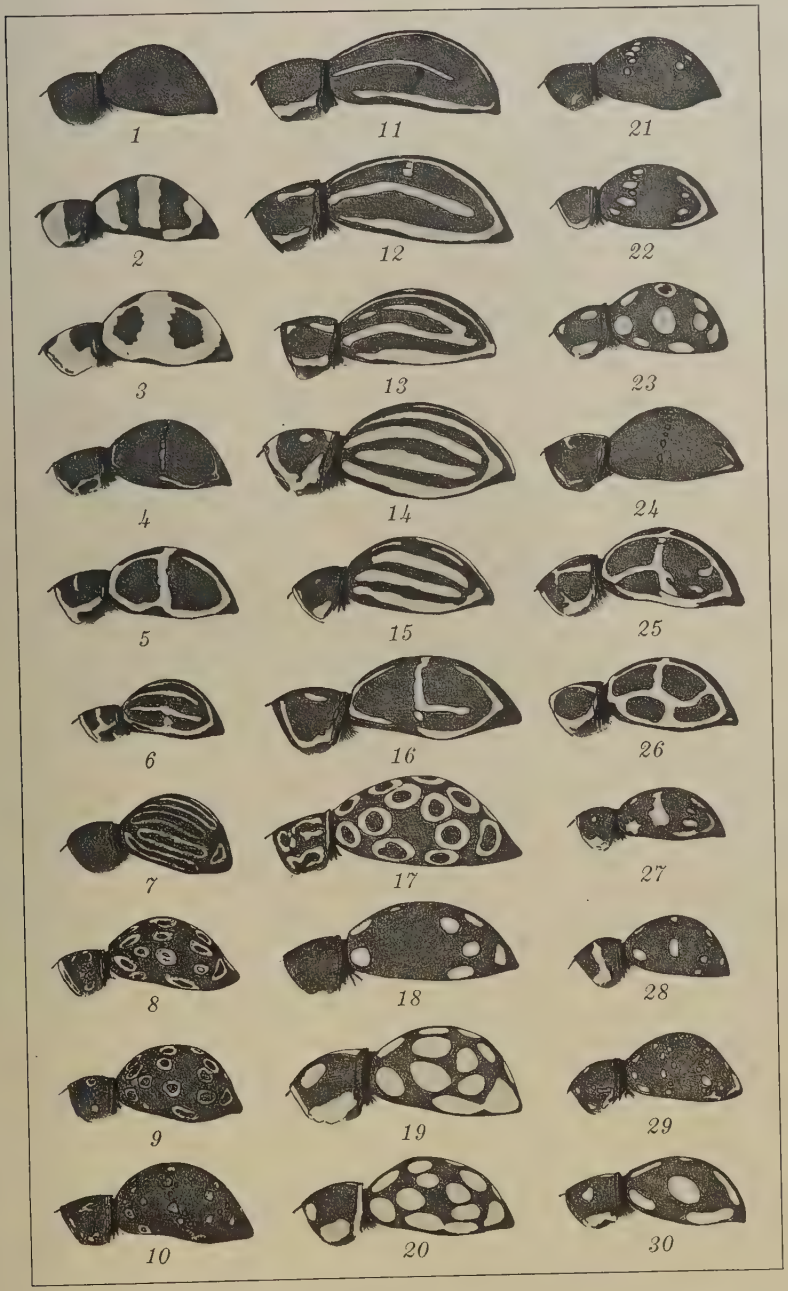
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PLATE 1.

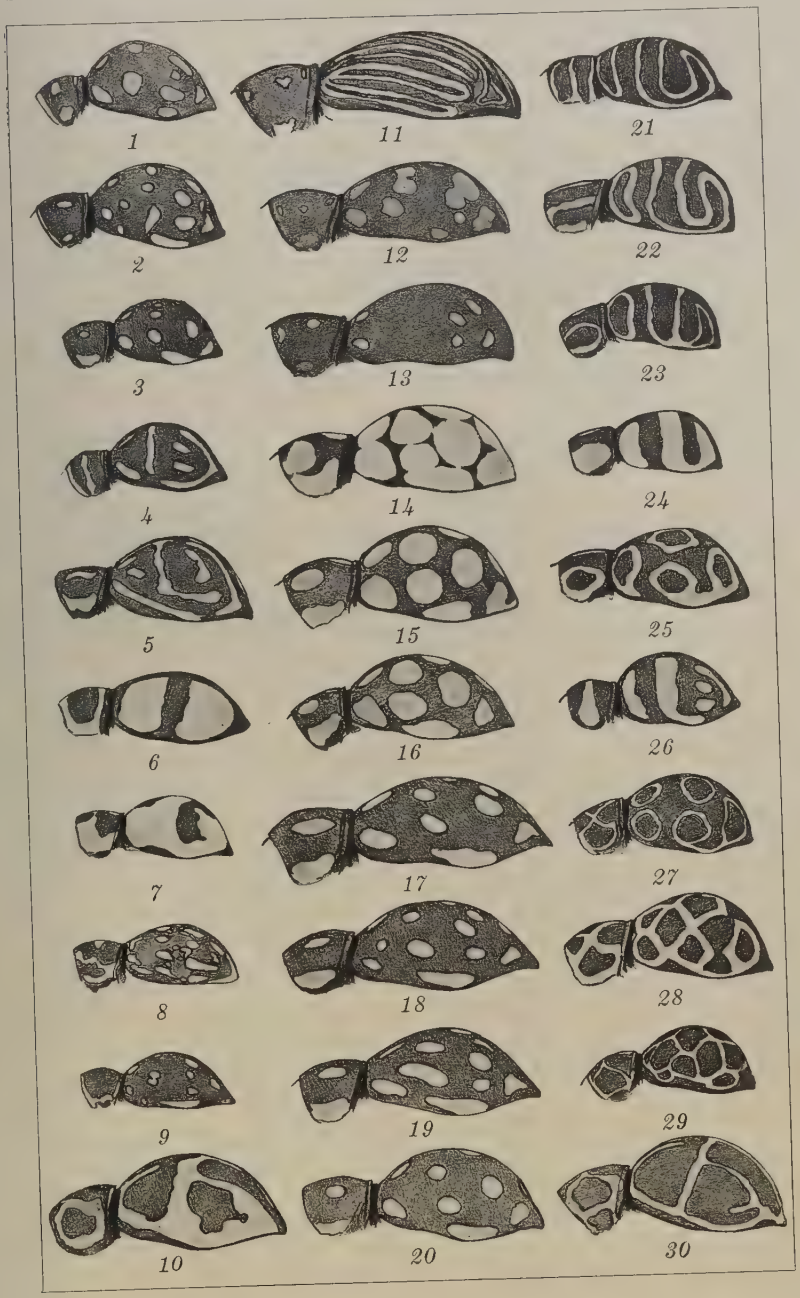
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PLATE 2.

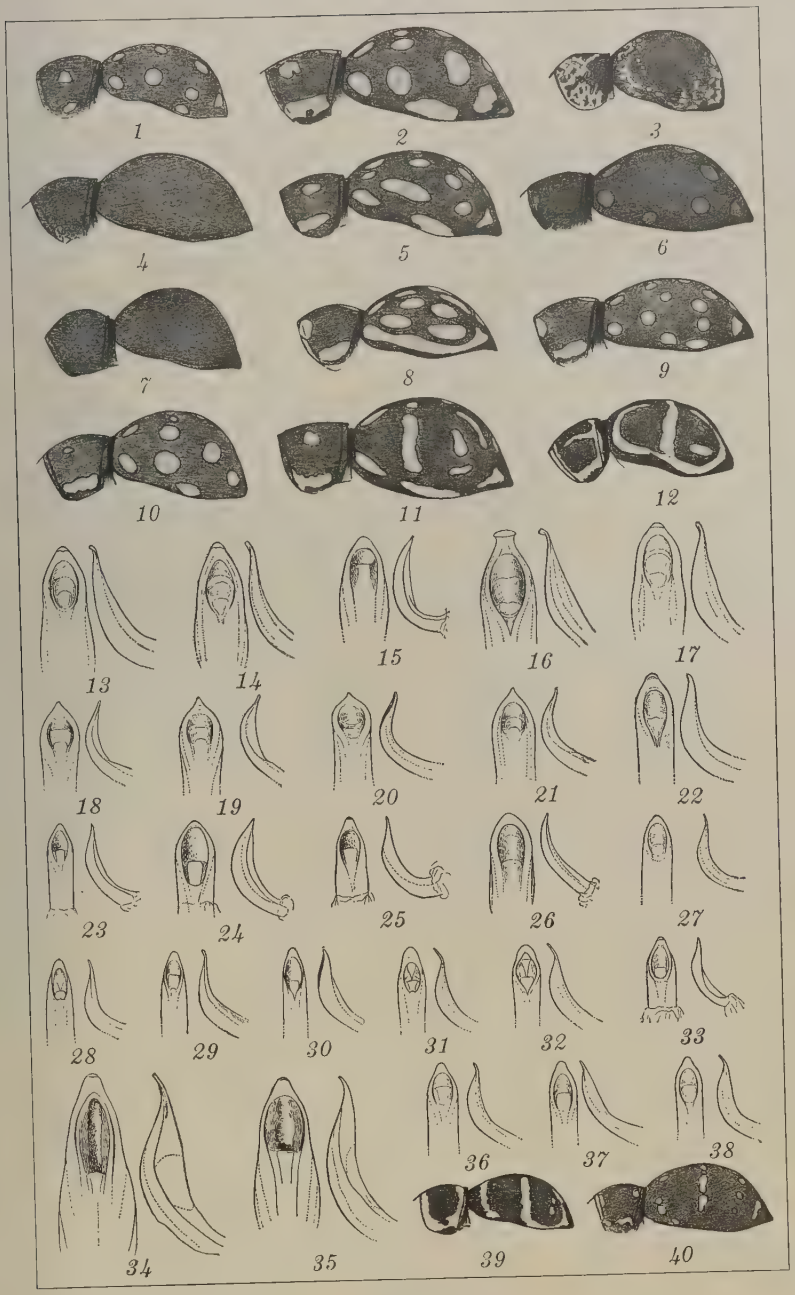
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PLATE 3.

PLATE 4.

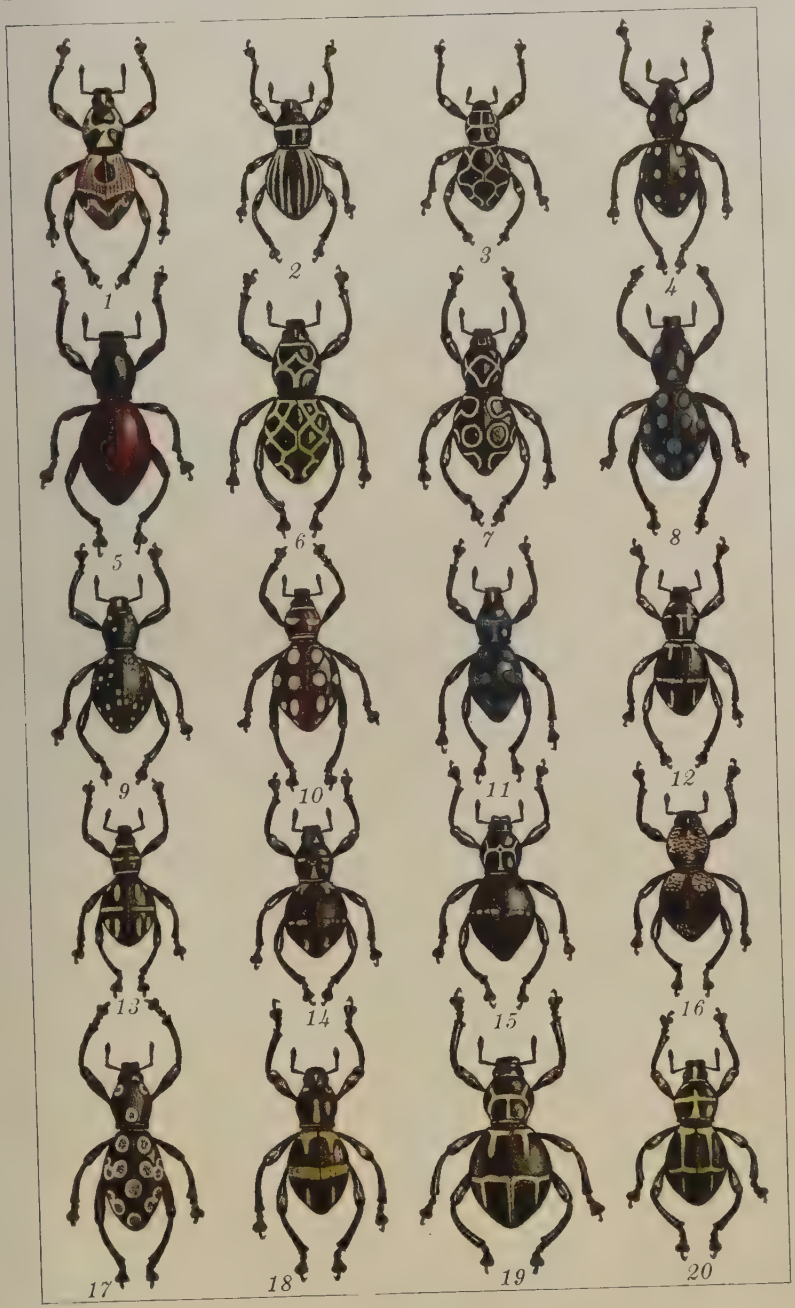

PLATE 5.

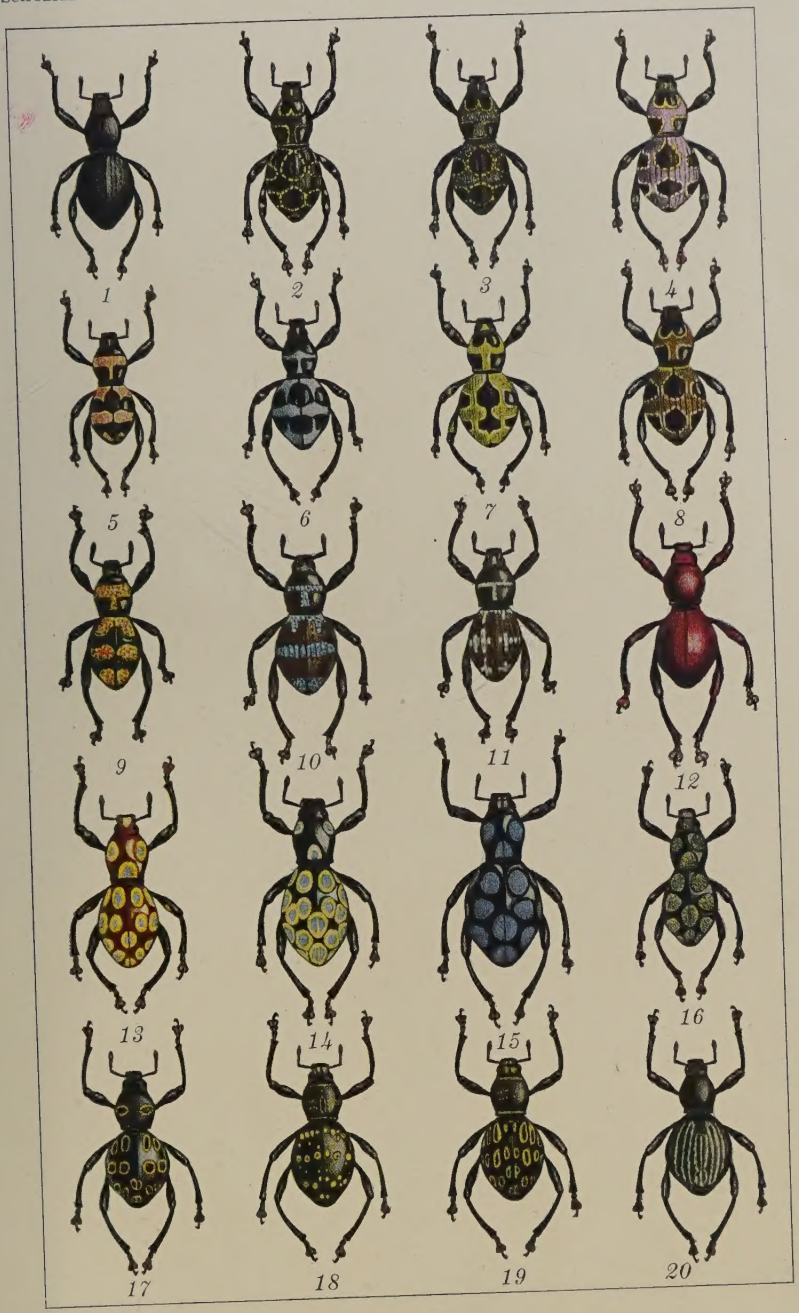

PLATE 6

ERRATUM

Page 330, line 29, *for* imen in von Winthem's *read* imen of *mediana* in von Winthem's.